# SERVICE MANUAL
# MODEL 48
# PHASE JITTER METER

Manufactured by

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# 1. INTRODUCTION

## 1.1 General Description

The Model 48 PHASE JITTER METER is designed to measure the phase modulation or "jitter", short term amplitude variations and amplitude dropouts resulting from signal transmission through a voice frequency communications channnel. High speed data transmission of 1200 bits per second and above are particularly sensitive to these parameters, which rank in importance with signal-to-noise ratio, inpulse noise, frequency response, and envelope delay distortion in determining noise, frequency response, and envelope delay distortion in determining channel error performance. Phase jitter and amplitude variations may be introduced by the transmission medium and the terminating, multiplex, carrier and radio equipments. The capability of measuring these important performance parameters and isolating those transmission links or equipments which are causing unacceptable performance is an important and necessary function in maintaining a high grade of service.

The Model 48 PHASE JITTER METER measures peak-to-peak phase jitter, phase hits, amplitude hits, amplitude dropouts, and coincident amplitude/phase hits introduced on a 990 to 1030 Hz carrier transmitted through the voice frequency channel under test. A CAUTION indicator warns of incorrect input frequency or level. A switchable 4-millisecond delay on the phase and amplitude hits is provided. The magnitude of the peak-to-peak phase jitter is displayed on a meter while the remaining measurements are displayed on individual mechanical totalizers.

The unit is completely self-contained and incorporates a transmit test tone oscillator for making loop measurements without additional equipment. End-to-end measurements may be made using a second Model 48 or any good quality audio oscillator as a test tone source. A 60 minute timer allows unattended collection of data over preset intervals. When totalized data is not required, flashing indicator lamps may be used in place of the mechanical totalizers. An external jitter output is provided to allow chart recording or spectrum analysis, and the external carrier output may be used to accurately measure frequency offset and provide a synchronizing signal for observing phase jitter on an oscilloscope. The phase hits, amplitude hits, coincident phase/amplitude hits, and dropout indicator logic signals are made available through external BNC connectors for use in further defining hit and dropout characteristics.

The portable Model 48 is self-contained in a hinged cover transit case.

## 1.2 Specifications

The mechanical and electrical specifications for the Model 48 PHASE JITTER METER are contained in Table 1-1.

A photograph of the Model 48 is shown in Figure 1-1.

TABLE 1-1

SPECIFICATIONS

| | |
|---|---|
| **INPUT** | |
| Frequency | 990 - 1030 Hz |
| Level | -40 to +10 dBm |
| Impedance | 135 Ω, 600 Ω, 900 Ω bridge (25,000 Ω) |
| Line Hold | 135 Ω, 600 Ω, 900 Ω positions |
| Line Hold dc Resistance | 250 Ω (maximum) |
| Longitudinal Balance | Greater than 50 dB<br>60 Hz to 4.0 kHz |
| **TRANSMIT OUTPUT** | |
| Frequency | 1015 Hz ±5 Hz |
| Level | -40 to 0 dBm |
| Impedance | 600 Ω |
| **METER** | |
| P-P Phase Jitter | $3^{\circ}$ and $30^{\circ}$ full scale (±5% of reading plus $\pm 0.2^{\circ}$) |
| Input/Output Level | -20 to +2 dBm (±1.0 dB) |
| **PHASE HITS COUNTER** | |
| Threshold Levels (peak) | $5^{\circ}$ steps, $5^{\circ}$ to $45^{\circ}$ |
| Hit Resolution | 145 ms |
| Maximum Count Rate | 7/sec |
| Hit Delay (IN) | 4 ms |
| **AMPLITUDE HITS COUNTER** | |
| Threshold Levels | ±1, 2, 3 and 6 dB |
| Hit Resolution | 145 ms |
| Maximum Count Rate | 7/sec |
| Hit Delay (IN) | 4 ms |
| **COINCIDENCE COUNTER** | |
| Minimum Coincidence Duration | 1 ms |
| Maximum Count Rate | 7/sec |
| **DROPOUTS COUNTER** | |
| Threshold Level | -12 dBm |
| Minimum Dropout Duration | 4 ms |
| Maximum Count Rate | 7/sec |

TABLE 1-1 (Cont)

| | |
|---|---|
| EXTERNAL JITTER OUTPUT | |
| Impedance | 22 kΩ |
| Level | 75 mV/degree (approximate) |
| EXTERNAL CARRIER OUTPUT | |
| Impedance | 6.3 kΩ |
| Level | 8 V pp |
| EXTERNAL LOGIC OUTPUTS (ALL) | |
| Impedance | 2.2 kΩ |
| Level | No hit 0. V<br>Hit +15. V |
| TIMER | 0 -60 minutes with HOLD |
| VOLTAGE | 105 to 125 V ac, 47-400 Hz |
| POWER | 20 watts |
| DIMENSIONS | 8" (20.3 cm.) H x 14" (35.6 cm.) W x 9.5" (24.1 cm.) D {with cover} |
| WEIGHT | 16 lbs. (7.3 kg.) |

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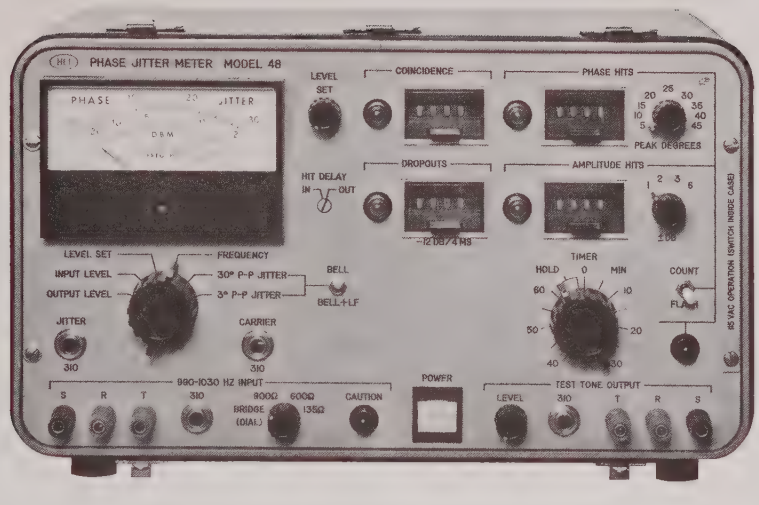
HLI reserves the right to make changes in specifications at any time without notice.




FRONT VIEW

REAR VIEW

FIGURE 1-1. MODEL 48 PHASE JITTER METER

# 2. INSTALLATION

## 2.1 General

The Model 48 PHASE JITTER METER is designed for ease of operation and installation. After the unit has been removed from its shipping container, perform a complete external visual inspection for possible damage.

To inspect the interior of the portable unit, open the cover and detach it from the case. Remove the two screws along the right and left hand edges of the panel and remove the inner assembly from its case. Any damage due to shipping should be immediately reported to the shipping agency.

All internal adjustments have been set at the factory and no further adjustment is required prior to installation or use of the equipment.

## 2.2 Unit Installation

Primary power is supplied through the line cord packed in the compartmented cover of the transit case. The cover may be opened by pressing the gray tabs of the latches holding the compartment lid. The cord is connected to the ac receptacle located through the access hole on the right hand side of the instrument.

Signal input/output lines are connected to the front panel binding posts or Western Electric 310 type jacks. Shielded cabling is recommended for all input/output connections.

Connection to the JITTER and CARRIER jacks is made using a standard Western Electric 310 tip-ring-sleeve phone plug. The phase hit, amplitude hit, coincident hit, and dropout outputs are available externally on BNC connectors at the rear of the unit.

For fixed station applications, an optional rack mounting shelf is available. This shelf mounts in a standard 19" relay rack and occupies 1-1/4" of vertical rack space. The depth behing the panel is 12" which includes storage provisions for the transit case cover.

# 3. OPERATION

## 3.1 General

This section contains a description of the controls and indicators, operating procedures and methods of measurement to be used with the Model 48. Prior to operation, be sure that all connections to the instrument are made in accordance with the instructions of Section 2. A photograph of the Model 48 is shown in Figure 1-1.

## 3.2 Controls and Indicators

The controls and indicators used in operating the Model 48 are described in Table 3-1. All controls are located on the front panel. No internal adjustments are required during normal operation. Adjustment procedures for internal controls are contained in Section 5.

TABLE 3-1

CONTROLS AND INDICATORS

| Designation | Reference | Function |
|---|---|---|
| POWER Switch and Indicator Lamp | S101<br>DS101 | Applies ac primary power to the instrument. |
| INPUT Terminals | J101, 102, 103, 104 | Provides input connections for wire leads, clip leads, banana plugs and Western Electric 310 type plugs. |
| INPUT Switch | S105 | Selects input line terminations of 135 Ω, 600 Ω, 900 Ω, or bridging (25,000 Ω). Line hold provided in 135 Ω, 600 Ω, and 900 Ω positions. |
| METER Switch | S102 | Selects the input to the front panel meter, measures input/output level, peak-to-peak jitter, level set, and frequency. |
| METER | M101 | Displays the parameter selected by meter switch S102. |
| LEVEL SET Control | R120 | Sets input signal to an internal reference level of 0 dBm. |
| CAUTION Indicator | DS105 | Glows when either the input level or frequency is incorrect. When active, inhibits all hit counters. |
| BELL/BELL + LF Switch | S901 | Selects the jitter frequency measurement band of 20-300 Hz or 3-300 Hz. |

TABLE 3-1 (Cont)

| Designation | Reference | Function |
|---|---|---|
| PEAK DEGREES Switch | S103 | Selects the threshold degrees (peak) which must be exceeded by phase hits to be totalized on the phase hits counter. |
| PHASE HITS Counter | L102 | Totalizes the number of phase hits exceeding the level set by S103 |
| PHASE HITS Indicator Lamp | DS102 | Flashes when a phase hit is detected and S106 is in the FLASH position. |
| ±DB AMPLITUDE HITS Switch | S104 | Selects the dB threshold which amplitude fluctuations must exceed before being totalized on the amplitude hits counter. |
| AMPLITUDE HITS Counter | L103 | Totalizes the number of amplitude hits exceeding the level set by S104. |
| AMPLITUDE HITS Indicator Lamp | DS103 | Flashes when an amplitude hit is detected and S106 is in the FLASH position. |
| HIT DELAY Switch | S107 | IN position rejects all phase and amplitude hits of less than 4.0 milliseconds duration. |
| COINCIDENCE Counter | S104 | Totalizes the number of coincident phase/amplitude hits which exceed their respective thresholds. Will count multiple hits from one source during an extended duration hit from the other source. |
| COINCIDENCE Indicator Lamp | DS104 | Flashes when coincident phase/amplitude hits are detected and S106 is in the FLASH position. |
| DROPOUTS Counter | L105 | Totalizes the number of dropouts which fall below -12 dBm for longer than 4 milliseconds. |
| DROPOUTS Indicator Lamp | DS106 | Glows during a dropout in both the COUNTER and FLASH positions of S106. |
| TIMER | S108 | Automatic timer to allow unattended accumulation of data for known time intervals. Continuous operation provided in HOLD position. |
| TIMER Indicator Light | DS107 | Glows when the TIMER is on. |
| COUNT/FLASH Switch | S106 | Selects the operation of either the counters or hit indicator lamps. |

TABLE 3-1 (Cont)

| Designation | Reference | Function |
|---|---|---|
| CARRIER Jack | J109 | Provides the phase locked oscillator signal between tip and ring/sleeve (gnd). |
| JITTER Jack | J110 | Provides the demodulated phase jitter output between tip and ring/sleeve (gnd). |
| OUTPUT Terminals | J105, J106, J107, J108 | Provides connection to the transmit oscillator for wire leads, clip leads, banana plugs and Western Electric 310 type plugs. |
| OUTPUT LEVEL Control | R103 | Controls the level of the transmit oscillator output. |
| PHASE HITS (P) Output | J111 | BNC connection for event recording of phase hits. |
| AMPLITUDE (A) HITS | J112 | BNC connection for event recording of amplitude hits. |
| COINCIDENCE HITS (C) | J113 | BNC connection for event recording of coincidence hits. |
| DROPOUTS (D) Output | J114 | BNC connection for event recording of the full duration of a dropout. |
| LINE receptacle | J115 | Connect ac line to unit. |

## 3.3 Operating Adjustments

This section presents the operational adjustments used with the Model 48. These adjustments are summarized in the OPERATING INSTRUCTIONS on the storage compartment lid located in the cover of the portable case.

### 3.3.1 General

All adjustments and measurements are made in a voice frequency channel using a test signal. The test signal frequency should be between 990 Hz and 1030 Hz which accommodats both the conventional 1004 Hz and 1020 Hz T carrier test signals. Measurements are generally made at a test level of -13 dBm. The test set will accept input levels from -40 to +10 dBm.

Operating adjustments are made using the actual test signal from the channel. Measurements and adjustments may be made with the test tone output from a Model 48 or any good quality audio oscillaotr. To verify proper instrument operation, the local 1015 Hz output signal is looped to the input. Operational checkout procedures are described in Section 5.2.

### 3.3.2 Transmit Initial Adjustment

In accordance with Bell System practice, the output level meter always displays the level that would exist if the output were terminated in 600 Ω. To use the Model 48 as a test tone source, first adjust the output LEVEL control for a -13 dBm0 signal using the OUTPUT LEVEL meter switch position. Then connect the OUTPUT terminals to the circuit under test. If the desired level is below -20 dBm, an external level meter may be used in adjusting the LEVEL control, or the following procedure may be used. Loop the output to the terminated input and adjust the output LEVEL control for a level 12 dB higher than required. Adjust the LEVEL SET control for a meter reading of 0 dBm. Now reduce the output LEVEL control until the CAUTION lamp comes on. The output is now set at the required level. As discussed in Section 3.4, test signal levels other than -13 dBm0 may be used when required.

When using a commercial osicllator, be sure both the frequency and level are correct.

### 3.3.3 Receive Initial Adjustment

Connect the channel under test to the 990-1030 HZ INPUT terminals of the Model 48, using either the 5-way binding posts or the Western Electric 310 type jack. Select the desired terminating impedance, and verify the proper input signal level using the INPUT LEVEL meter position, and the proper input signal frequency using the FREQUENCY meter position. Any test signal frequency outside the range of 990 to 1030 Hz will appear as an off scale or center scale reading with an illuminated CAUTION lamp. Place the meter switch in the LEVEL SET position, and adjust the LEVEL SET control for a 0 dBm reading. This sets the dropout reference level so that if the input level drops 12 dB below this fixed level for greater than 4 ms, a dropout will be measured. When the above adjustments have been properly completed, the CAUTION indicator will extinguish. If the CAUTION lamp remains illuminated, verify that the test signal frequency and level are within the operating ranges of the Model 48.

### 3.3.4 CAUTION Lamp

The CAUTION lamp will illuminated whenever the test signal frequency is outside the 990 to 1030 Hz range or a dropout condition exists. The CAUTION lamp must be extinguished before valid measurements can be made. During a caution period, all hit counters are disabled and no hit data will be accumulated.

Following a caution period, internal delay circuitry allows the test set to stabilize before the hit counters are returned to operation.

### 3.3.5 Phase Jitter

Following proper adjustment of the LEVEL SET control and the extinguishing of the CAUTION light, phase jitter measurements may be made. Select the lowest peak-to-peak jitter range which gives a consistent on scale reading. When short term fluctuations of the phase jitter are present, the meter reading should be averaged to determine a final measurement figure.

### 3.3.6 PHASE HITS and AMPLITUDE HITS

To measure phase and amplitude hits, the desired threshold levels should be selected on the PEAK DEGREES switch and the ±DB switch. To totalize measurements on the mechanical counters, place the COUNT/FLASH switch in the COUNT position. If blinking light indications are desired, place this switch in the FLASH position. Before measured data is taken with the counters, reset them to 0 by pressing the manual reset level located on each counter. To initiate a measurement, turn the TIMER knob to the desired timer interval. For intervals of less than 10 minutes, the knob must be turned past the 10 minute position and returned to the desired interval. If continuous operation is desired, turn the TIMER knob fully clockwise to the HOLD position. The timer controls the operation of both the counters and the blinking lights.

WARNING: Do not attempt to turn the TIMER knob directly counterclockwise from the OFF position to the HOLD position. This will damage the timer.

### 3.3.7 Coincidence Hits and Dropouts

The measurement of coincident hits and dropouts are made automatically whenever the timer is on. Operation of the COINCIDENCE HIT counter or blinking light indicator is selected by the COUNT/FLASH switch.

The DROPOUTS indicator light will be illuminated duting a dropout condition regardless of the COUNT/FLASH switch position. The DROPOUTS counter will operate only in the COUNT positon.

A dropout occurrence greater than 4 ms will produce the dropout count. During the dropout period, the CAUTION lamp will illuminate and the hit counters will be disabled. When the dropout is over, internal delay circuitry allows the test set to stabilize before the hit counters are returned to operation and no additional hits are accumulated.

### 3.3.8 Hit Delay

Short duration phase and amplitude hits can be caused by impulsed noise. To eliminate the measurement of phase and amplitude hits due to impulse noise, a 4.0 millisecond hit delay is provided which requires a hit to be present for at least 4 milliseconds before it is measured. The hit delay may be disabled by turning the screwdriver adjusted HIT DELAY switch on the front panel to the OUT position.

### 3.3.9 Frequency Offset Measurement

Frequency offset measurements may be made with an electronic frequency counter connected to the tip (signal) and the ring/sleeve (gnd) connections of the CARRIER jack. This output is the phase locked signal which is locked in frequency and phase to the input signal. The phase locked loop effectively provides a narrow band filter of approximately 20 Hz around the test signal resulting in an almost noise free CARRIER output. Extremely accurate and stable measurements may be made even in a noisy channel, normally not suitable for direct frequency offset measurements with an electronic frequency counter.

The CARRIER output may also be used to snychronize an oscilloscope used to observe the channel test signal.

### 3.3.10 External Jitter Output

The demodulated jitter signal is also available on the tip (signal) and ring/sleeve (gnd) of the JITTER jack. This signal may be used for spectrum analysis of the jitter modulation to determine individual jitter frequencies and their magnitude, and it may also be directly recorded on a high speed strip chart recorder.

### 3.3.11 External Counter Outputs

The dc logic voltages used to drive the counters and/or blinking lights are brought out to individual BNC connectors located on the rear of the unit. A maximum counting rate of 7 pps assures reliable operation of the electro-mechanical counters and is compatible with existing Bell System standards. These outputs may be used to make chart recordings of hit and dropout occurrences which then provide a permanent record and detailed picture of circuit performance.

## 3.4 Measurement Methods

This section presents a general discussion of phase jitter, and the various ways in which the Model 48 may be used to measure this important parameter.

### 3.4.1 General

Phase modulation or "phase jitter" introduced by voice frequency transmission facilities has an insignificant effect on voice intelligibility, but can introduce errors in data transmission. Just as signal amplitude is affected by channel induced amplitude noise, i.e., thermal, crosstalk, etc., the phase of the signal is affected by channel induced phase jitter. Phase jitter generally occurs during a frequency translation process where power supply hum and power line and ringing frequency ground currents phase modulate the translation oscillators. The resultant jitter has a nominal background which is displayed on the meter, as well as occasional abrupt changes or hits that are detected by the phase hits counter.

Apparent phase jitter effects may also be generated by other channel parameters, principally additive wideband noise, spurious signals (crosstalk, etc.) and amplitude impulse noise. These parameters are independently specified and measured in evaluating channel performance, and their effect on the phase jitter measurement has been minimized in the design of the Model 48. Wideband noise, however, may still be a source of error in the phase jitter measurement, and this will result in readings higher than the actual jitter level. Figure 3-1 shows the error which will result as a function of test signal-to-noise level ratios for true phase jitter levels of $11.4^{\circ}$ and $1^{\circ}$. The test signal-to-noise ratio may be improved by increasing the test tone level up to the point of channel nonlinearity; this, however, is generally not recommended.

Degradation in T carrier channels is the result of quantizing noise effects rather than the direct phase or frequency modulation of the voice frequency signal. Valid phase jitter measurements may be made over tandem circuits utilizing T carrier; they are not, however, necessarily indicative of the T carrier channel quality.

Amplitude hits are short term changes in transmission loss which result from a number of causes including automatic level equalization, microwave combiner switching, etc. Amplitude hits are distinct from amplitude impulse noise. For very high values of impulse noise, however, test signal level changes may result which appear to be amplitude hits. The sensitivity of hit measurements to impulse noise is minimized by the hit delay circuitry incorporated in the Model 48.

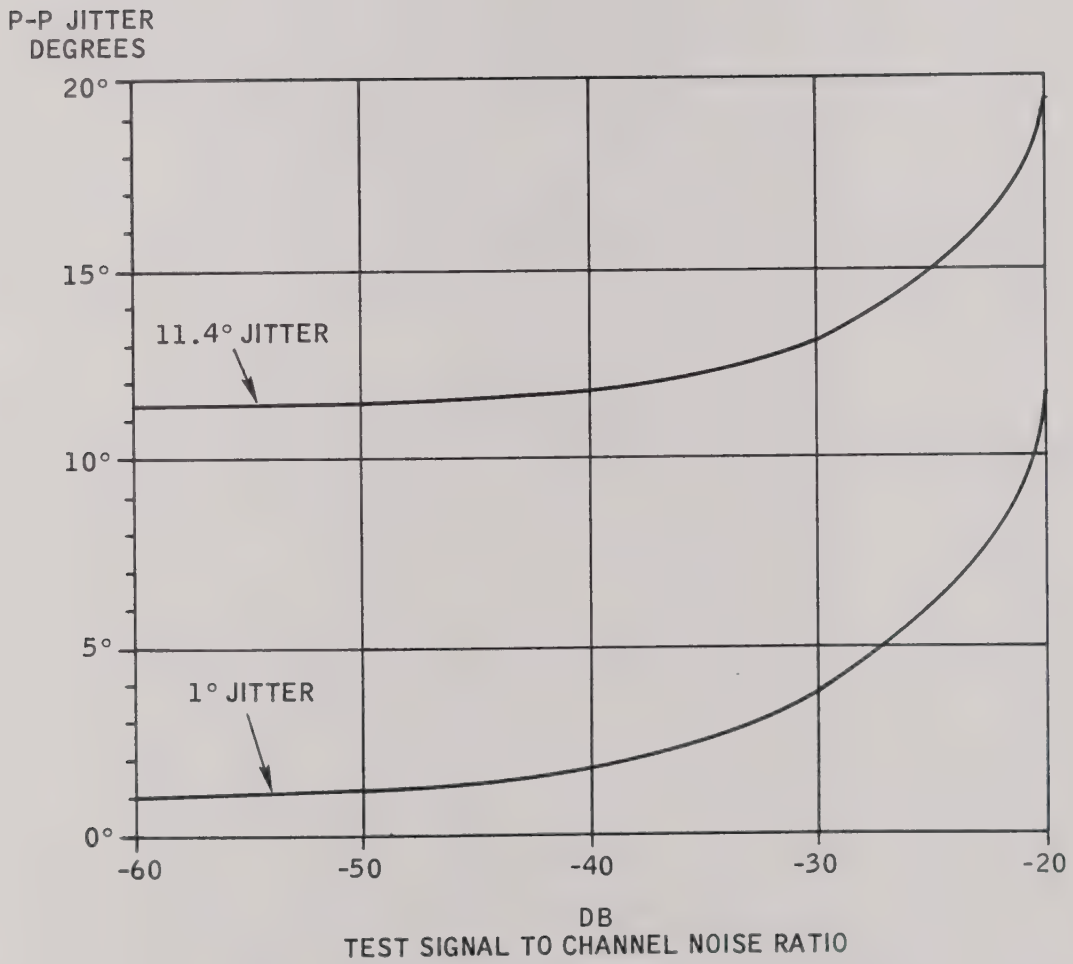



FIGURE 3-1. ERROR IN P-P JITTER READINGS RESULTING FROM VOICE FREQUENCY CHANNEL NOISE

The coincidence hits mode measures the number of coincident phase and amplitude hits. This is valuable in determining the source of circuit hits. Certain circuit disturbances will generate simultaneous phase and amplitude hits, while others will generate only one type.

Dropouts are measured in accordance with Bell specifications, and are defined as a 12 dB decrease in level for 4 milliseconds or longer. Continuous monitoring and detection of this parameter is virtually the only means of detecting its presence.

### 3.4.2 End-to-End Measurements

End-to-end measurements are made as shown in Figure 3-2. The test tone signal may be obtained from the OUTPUT of the Model 48 or a commercial oscillator. Either balanced or unbalanced circuits may be connected to the input/output of the instrument. The transmission test level is typically -13 dBm0. The instrument is adjusted and measurements are made in accordance with the operating adjustments of Sections 3.3.

To locate sources of excessive phase jitter on a long distance point-to-point circuit, test signal transmissions from various voice frequency drop points may be used to isolate the segment of the circuit causing excessive jitter. The same technique may also be used in isolating local sources of jitter, by transmitting test signals from various test points within a facility or equipment.

### 3.4.3 Loop Measurements

When a far end test signal source is not available or it is inconvenient to make end-to-end tests, loop measurements may be performed as shown in Figure 3-3. At the distant end, the received level and desired transmit level must be matched; i.e., if the specified transmit and received levels are not equal, it is essential that an amplifier or attenuator network be used to match them. This must be done to preserve the signal-to-noise ratio of the test signal and to eliminate overloading of the transmission facility.

Loop measurements are not as desirable as end-to-end measurements. In general, one cannot assume that the total phase jitter measured on a looped basis is equally divided between the transmit and receive circuits. In some cases, the phase jitter in each direction may tend to cancel, and unlike channel noise, will result in a lower overall loop measurement than the sum of individual end-to-end measurements.

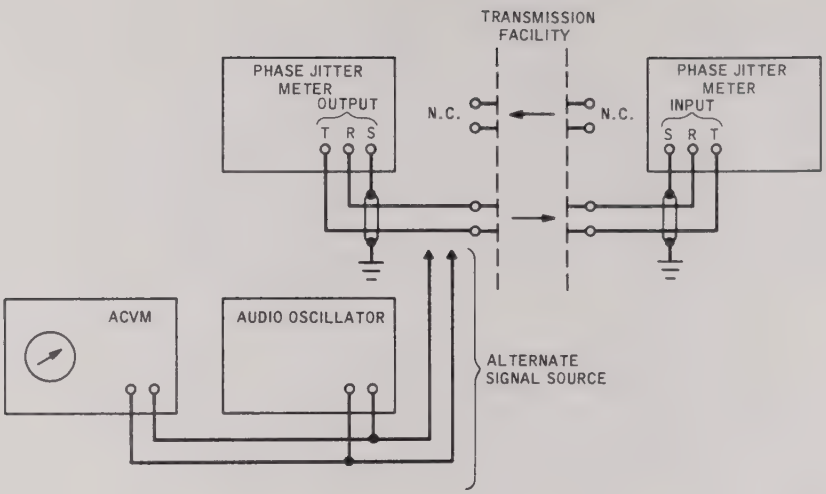



FIGURE 3-2. END-TO-END MEASUREMENT

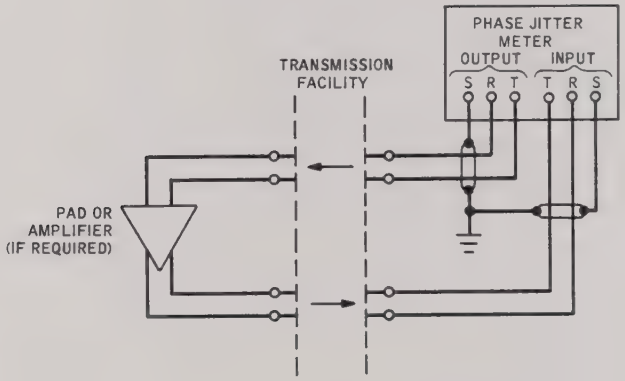



FIGURE 3-3. LOOP MEASUREMENT

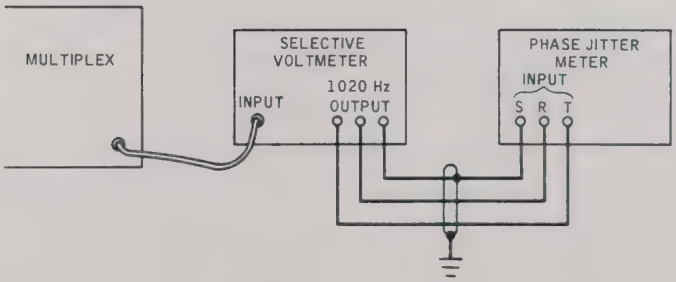



FIGURE 3-4. HIGH FREQUENCY CARRIER MEASUREMENT

### 3.4.4 Direct High Frequency Carrier Measurement

For direct carrier measurements between 10.0 kHz and 10.0 MHz, a carrier pilot option is offered for the Model 48 which allows direct measurement of any carrier pilot frequency. Such measurements are desirable when performing maintenance on various multiplex and carrier equipments and this capability extends the usefulness of the instrument. Typical measurement frequencies are 3.100 MHz and 3.396 MHz. With this option, an additional input selector switch and Western Electric 75 Ω coax connector are provided on the front panel, and the carrier pilot level is directly displayed on the INPUT LEVEL position of the meter. The unit maintains its full voice frequency capability.

### 3.4.5 High Frequency Carrier Measurement

The Model 48 PHASE JITTER METER may be used with additional equipment to measure phase jitter on carriers in a group or supergroup baseband. To measure high frequency carriers, it is necessary to use a frequency translation device to heterodyne the desired carrier to 990 to 1030 Hz. This is done using a tuneable selective voltmeter having a translated voice frequency output.

A typical equipment connection is shown in Figure 3-4. The selective voltmeter is tuned to the desired carrier, oscillator, or pilot tone frequency, and the translated output is connected to the INPUT of the Model 48. The bandwidth of the translation device should be greater than 800 Hz but not more than 4 kHz.

When small magnitudes (less than $3^{\circ}$) of phase jitter are sought using this technique, the signal-to-noise ratio at the output of the slective voltmeter must be taken into account in determining the true value of phase jitter (see Figure 3-1). It is also possible that the translation device itself may introduce jitter in the translated signal; this may be verified by measuring a carrier source having known jitter.

# 4. THEORY OF OPERATION

## 4.1 General

This section provides a general theory of operation followed by detailed circuit operation on a functional block basis. The Model 48 is entirely solid state and makes extensive use of integrated circuit differential operational amplifiers and conventional discrete components. Two types of differential operational amplifiers are used in the unit. The externally compensated Type MC1437 operational amplifier is used where wide bandwidth and fast rise times are required, and the internally compensated Type RC4558P operational amplifier is used where a 10 kHz bandwidth is adequate. Discussions of operational amplifier configurations and operation are available in a number of current reference texts. Conventional transistors are used in the remainder of the circuitry. A simplified block diagram of the Model 48 is shown in Figure 5-3.

### 4.1.1 Input

The balanced or unbalanced input signal is terminated by the input switch in 135 Ω, 600 Ω, 900 Ω, or bridging impedances. Line holding is provided in the 135 Ω, 600 Ω, and 900 Ω positions by a holding coil. Dual isolating capacitors precede the input transformer and block the dc voltages which appear at the input. The transformer is connected to a 5-pole low pass filter which attenuates spurious signals and noise above 3.0 kHz. This filter is followed by a level set amplifier whose gain is manually set to provide a 0 dBm reference level for the dropout measurement.

### 4.1.2 Phase Jitter Measurement

The filtered 0 dBm input signal from the level set amplifier is routed to the signal limiter which provides a square wave replica of the input signal zero crossings; the resultant is one input to the digital phase detector. This detector compares the input signal with the long time constant phase locked reference oscillator and generates dc pulses whose widths are proportional to the phase difference. These pulses are then changed to a dc voltage proportional to that phase difference by the 300 Hz low pass filter. This filter's output is used to control the phase locked reference oscillator, and supplies the phase jitter signal to the phase hits detector and peak-to-peak jitter detector. The phase hits detector is followed by a 4.0 millisecond hit delay circuit which is designed to reduce measurement sensitivity to impulse noise by requiring that a

phase hit be present for a minimum of 4 milliseconds before its occurrence is passed on to the phase and coincident hit drivers.

The signal limiter also supplies an input to the out-of-lock detector, which is combined with output of the dropout detector to generate the CAUTION light indication. The caution detector output is used to inhibit all of the hit counters/lights during a caution condition and ensures that no invalid data is accumulated.

### 4.1.3 Amplitude/Dropout Measurement

The filtered 0 dBm input signal from the level set amplifier is also applied to the amplitude detector, which consists of a full wave rectifier feeding a 300 Hz low pass filter identical to that following the digital phase detector. The filters's dc output, which is proportional to the input level, is applied to the amplitude hit reference amplifier and the plus and minus amplitude hit detectors. These circuits detect amplitude variations exceeding the preset threshold values, and the plus and minus hit outputs are combined prior to the 4.0 millisecond hit delay circuitry. The hit delay output provides a signal to the amplitude hits driver and to one input of the coincidence detector, which detects simultaneous phase and amplitude hits and furnishes the input to the coincident hits driver.

The filtered dc amplitude output signal is also used to detect dropouts. When the dropout detector measures more than a 12 dB decrease in the input signal level for a period of 4 milliseconds, a dropout condition is generated. The dropout signal is used as an input to the caution detector and to the dropout driver and indicator.

## 4.2 Detailed Circuit Operation

### 4.2.1 Line Input (48-201 Board)

The input signal is connected using the 5-way binding post or a Western Electric 310 type jack. Both balanced and unbalanced signals may be accommodated. The input is terminated by the INPUT switch S105, and dc holding coil L101 is connected across the input in the 135 Ω, 600 Ω, and 900 Ω termination positions. In the BRIDGING position (approximately 25 kΩ input impedance), the holding coil is removed to allow dial through operation. The signal is then applied to the two dc isolating capacitors C201 and C202 which also reject 60 Hz pickup on the line. The filter's output is connected to the input transformer

T201 which performs the balanced to unbalanced transformation. The transformer secondary feeds a low pass filter IC201B, IC202B, which provides a 5-pole Butterworth response using active filter techniques, eliminating the requirement for conventional inductors. Input voltage transient protection is supplied by diodes D201, D202. The output of IC202B provides the filterd input signal utilized by the input level set amplifier IC202A. The gain of the level set amplifier is controlled by the front panel LEVEL SET control R120 and may be varied from -10 dB to +40 dB to provide a 0 dBm level at its output Pin G. Maximum gain is limited by R212, and C210 provides dc stabilization of the amplifier.

4.2.2 Signal Limiter (42-301 Board)

The input signal limiter IC301B is a differential operational amplifier used as an open-loop gain zero crossing detector with dc stabilization provided by R303, R306, and C339. Amplifier phase compensation is provided by C301, C303. This amplifier provides a square wave replica of the input signal zero crossings.

4.2.3 Digital Phase Detector (48-301 Board)

The output from IC301B and the phase locked reference oscillator output from IC302A are connected to the two inputs of the digital phase detector. Transistors Q301, Q302, and their associated components form an "exclusive or" gate which provides a bipolar output pulse whose width is proportional to the phase difference (zero crossing times) of the two inputs. The back-to-back Zener diodes D306, D307 provide a constant amplitude pulse to the circuitry that follows.

4.2.4 300 Hz Low Pass Filter (48-321 Board)

The carrier frequency present at the output of the digital phase detector is removed, and the upper limit of the phase jitter spectrum determined by the low pass filter consisting of IC1 and its related components. This filter provides a 5-pole 300 Hz low pass response using active filter design techniques. To achieve the desired bandwidth accuracy, 1% resistors and capacitors are used in this filter. The filter made up of R9, R10, and C2 controls the phase locked loop characteristic. The output of the active filter IC1A Pin 1 furnishes the signal to the FREQUENCY position of the panel meter through R4, R5 and the bias offset network R7, R8. The phase locked loop control voltage is obtained from the output of the filter through R16, R17. The filter response for the phase hit circuits is provided by IC2 and its related components.

4.2.5 Phase Locked Reference Oscillator (48-301 Board)

The output of the low pass filter is a dc voltage proportional to the instantaneous phase difference between the input and reference oscillator signals. This signal controls a conductance modulator consisting of Q310, Q311, Q312, D308, and D309. This circuit effectively varies the reactance across the "bridge tee" oscillator feedback circuit, and determines the output frequency and phase of the oscillator. The oscillator frequency is adjusted by trimmer R358. Its output is connected to reference limiter IC302A which provides a square wave replica of the phase locked oscillator signal to the digital phase detector.

4.2.6 20 Hz High Pass Filter (48-301 Board)

The output of the 300 Hz low pass filter is high pass filtered by IC304B, which is a 2-pole 20 Hz active filter, using C314, C315, R335, R337, R393, R394, and R395. This filter also provides isolation and signal amplification for the circuits that follow it.

4.2.7 Bell +LF Circuit (48-LF Board)

The phase locked loop control voltage is filtered and amplified by IC1A and IC2A. The output of IC2A is then summed with the normal jitter signal to extend the low frequency response to approximately 3 Hz.

In addition, when the LF mode is used, capacitors C6 and C7 are placed across the meter detector and the 20 Hz high pass filter is bypassed. The weighting characteristic for the jitter signal is selected by S109, BELL + LF switch.

4.2.8 Peak-to-Peak Detector (48-301 Board)

The jitter signal feeds the high linearity peak-to-peak detector consisting of amplifier IC304A, the positive peak detector Q307, and the negative peak detector Q308. The gain of the detector is controlled by the meter switch, providing near unity amplifier gain in the $30^{\sigma}$ position, and 10 times that gain in the $3^{\circ}$ position. R341 provides the calibration of the $30^{\circ}$ range and R342 adjusts the calibration of the $3^{\circ}$ range. The positive peak is stored on capacitor C318, and the negative peak on capacitor C317. Their outputs are applied to the meter through multiplier resistor R345. This detector is calibrated in terms of the peak-to-peak value of a sine wave and responds to approximately the 99% level of white noise.

4.2.9 Phase Hits Detector (48-301 Board)

The phase hits detector consists of the full wave rectifier IC305A, IC305B, and a variable threshold detector IC306A.

The jitter signal is applied to the full wave rectifier IC305 from the 48-321 board. This circuit provides a highly stable precision full wave rectifier, independent of diode offset characteristics. Its output represents the peak value of the phase jitter, as opposed to the peak-to-peak reading which is displayed on the meter. The output is connected to a threshold detector IC306A which compares this peak signal to the threshold level set by the PEAK DEGREES switch S103. The output of the threshold detector remains at a negative value until the peak phase jitter signal exceeds the threshold level. When this occurs, the output abruptly changes to a positive voltage until the input signal again falls below the threshold, returning the output to the negative level.

Phase hits greater than $90^{\circ}$ are detected by IC3A on the 48-321 board. Pin 1 of IC 3 is connected to the 4-millisecond delay circuit at Q309.

4.2.10 Four Millisecond Hit Delay (48-301 Board)

The output of the phase hits threshold detector is connected to a 4-millisecond hit delay circuit consisting of Q309, IC306B. When a phase hit occurs, Q309 is turned off, allowing C337 to charge towards the supply voltage. The time constant is selected so the capacitor voltage crosses the trigger amplifier threshold in 4-milliseconds, resulting in a change of state of the trigger amplifier output. This change is used to drive the phase hits counter driver circuitry and coincidence detector. If the phase hit is terminated prior to the 4-millisecond interval, C337 is immediately clamped to ground by Q309, thus terminating its charging cycle. Phase hits of less than 4-milliseconds duration will not generate an output, thus providing the desired immunity to impulse noise. The hit delay is present when the delay capacitor C337 is grounded at terminal V.

4.2.11 Phase Hits Driver (48-201 Board)

The phase hits, amplitude hits, coincidence hits and dropout counters, with their respective indicator lamps, use identical counter driver circuitry. A single explanation is given for the amplitude hits driver in Section 4.2.16, and this may be used with appropriate substitution of component designations for the other driver circuits.

4.2.12 Out-of-Lock Detector

The out-of-lock detector is used to detect an "out-of-range" lock or lack of phase lock in the reference oscillator. This is then combined with the dropout detector to illuminate the CAUTION lamp if either the phase lock or input level is incorrect.

The out-of-lock detector uses a digital phase detector Q303, Q304, similar to that of the jitter phase detector. It is driven by the input signal limiter IC301B and the out-of-lock limiter IC302B, which utilizes a $90^{\circ}$ phase shifted input signal obtained through the network R359, C308. This results in a maximum positive voltage output from the digital phase detector. As the input frequency is varied in either direction, the out-of-lock threshold detector IC301A provides a change of output when the acceptable phase lock range has been exceeded. When phase lock has not been obtained, the output voltage generates an out-of-lock indication from the threshold detector. The output of the digital phase detector is summed through R310, R319, with the threshold set voltage from R320. Hysteresis is provided in the threshold detector by R321, R322. When an out-of-lock condition exists, a positive voltage appears at the output of IC301A.

4.2.13 Amplitude Detector (43-201 Board)

The amplitude detector consists of a full wave rectifier IC201A, IC203A, similar in operation to the full wave rectifier of the phase hits detector IC305. This full wave rectifier uses diodes in the feedback network to provide a half wave rectified replica of the input signal at the junction of R216, D204. This signal is then summed by a ratio of 2 to 1 with the original signal through R217, R213, to provide the full wave waveform at the output of IC203A.

4.2.14 300 Hz Low Pass Filter (48-201 Board)

The full wave detector is followed by a 5-pole active 300 Hz low pass filter consisting of IC203B, IC204B. The filter configuration is similar to the 300 Hz low pass filter of Section 4.2.4. Different circuit values are utilized to provide an overall filter gain of 6 dB.

4.2.15 Reference Amplifier and Hits Detector (48-201 Board)

The output of the low pass filter is connected to the reference amplifier and hit detectors. Dual threshold detectors are set to change state whenever an increase or decrease in signal level occurs which exceeds the setting of the ±DB front panel switch S104. The outputs of these detectors are then combined to drive the amplitude hit delay circuitry.

The short term average of the filtered signal output is obtained by the time constant circuit R230, C223, and is applied to the input of the reference amplifier IC204A, and amplified by a factor of 2. The gain is controlled by the resistor divider network consisting of R113 through R119, and the amplitude hits ±DB switch S104 selects the voltages on this divider chain corresponding to ±1, 2, 3, or 6 dB levels, which become the reference inputs to the amplitude hit threshold detectors.

The threshold detectors IC205A and IC205B comapre the output of the 300 Hz filter, which contains the short term amplitude variations of the input signal, with the divided average values from the ±DB switch. A small hysteresis is provided by the feedback resistors R233 through R236, and compensation is provided by capacitors C216, C217, C219, C220. When an amplitude hit occurs which exceeds the threshold setting, the output of the appropriate threshold detector will change from a positive to a negative voltage, and this is applied to the 4-millisecond hit delay circuit through diodes D205, D206. The operation of the hit delay circuit consisting of Q230 and IC206B is identical to that described in Section 4.2.10. The output of the hit delay circuit is connected to the amplitude hits driver Q201 through Q206.

4.2.16 Amplitude Hits Driver (48-201 Board)

The amplitude hits driver is identical to the phase, coincidence and dropout drivers and the following explanation may be used for these circuits. The driver operates either the counter or the indicating lamp as controlled by the COUNT/FLASH switch S106.

The input signal is differentiated by the input capacitor C230A and the positive going edge is removed by D216A. The negative going pulse is applied through R276A to the multivibrator consisting of Q204, Q205. The multivibrator provides approximately a 70 millisecond "on" pulse followed by a 70 millisecond "off" pulse which is required for the mechanical counter operation. This results in a maximum count rate of 7 counts per second. The multivibrator output is amplified by Q202 which feeds the driver transitor Q201. Transient protection for the driver is provided by R285A and D217A. Inhibiting transistor Q206 is included in all except the dropout detector driver, and inhibits the multivibrator operation when a positive signal is applied. This eliminates the accumulation of invalid data during periods when a caution condition is present.

4.2.17 Coincidence Detector Circuitry

Coincidence between the phase and amplitude hits is detected by diodes D209, D210. These diodes will have a negative output only when both of the inputs have dropped to a minus voltage. When this occurs, a negative impulse is fed to the coincidence hits driver consisting of Q207 through Q212. See Section 4.2.15 for a description of the driver operation.

4.2.18 Dropout Detector (48-201 Board)

The dropout detector monitors the input signal level from the full wave rectifier and is activated when the input signal drops 12 dB below the reference level for a period exceeding 4-milliseconds. The reference level is set when the LEVEL SET control is adjusted for a 0 dBm meter reading in the LEVEL SET meter position.

The dropout detector consists of the threshold detector IC207A, IC207B and the timing circuit Q229, IC206A. The full wave rectifier output is connected to one input of the signal threshold detector IC207A where it is compared against the threshold voltage set by R246. This is factory set at -12 dB. The timing circuit Q229 and IC206A is identical to the hit delay circuit of Section 4.2.10. Capacitor C224 determines the dropout detector time constant and rejects dropouts having durations of less than 4-milliseconds.

The positive output of IC206A during a dropout condition drives the dropout driver circuitry through Q224. The dropout lamp is driven continuously through the Darlington pair driver Q225, Q226, so that it will remain lit during the entire dropout interval. The dropout signal is also used as one input to the caution indicator.

4.2.19 Loss-of-Tone Detector (48-221 Board)

The loss-of-tone detector monitors the input signal from the input transformer and is activated when the signal is lost even if it is replaced by an equivalent level of bandlimited noise.

The signal is first limited and then fed to IC3 where a short pulse is generated for each positive and negative going zero crossing. This pulse then fires a series of one-shots which generates a wider pulse approximately one half period later. If the next short pulse falls within this wider pulse, it will discharge C10. If the discharge pulses are not generated, C10 will charge up past the threshold set by R26, R28, and R29. This results in a dropout condition being detected.

4.2.20 Caution/Inhibit Circuitry (48-231 Board)

The caution/inhibit circuitry combines the dropout and out-of-lock detector outputs to illuminate the CAUTION lamp and inhibit the HIT counters whenever either condition exists.

The dropout detector fires a 70 ms and a 140 ms one-shot. These outputs are then combined with the dropout detector and out-of-lock detector outputs in OR gates to provide the proper inhibit pulses and control the CAUTION lamp driver.

4.2.21 Timer

The mechanical timer S108 controls the dc voltages to the counters and their associated indicator lamps. When the timer is ON, the timer ON/OFF lamp DS107 is illuminated.

4.2.22 Meter Circuit

INPUT/OUTPUT levels, P-P PHASE JITTER, LEVEL SET, and FREQUENCY are monitored using the front panel mounted 50 microampere meter. The meter input is selected by the meter switch S102. For level monitoring, a bridge rectifier consisting of D314, D315, and R390, R391, R392 with dc isolating capacitor C338, is used to rectify the audio voltages.

4.2.23 Transmit Oscillator (48-301 Board)

The transmit oscillator IC308 is a low distortion design using a gyrator in place of an inductor. Its output is connected to the output LEVEL control R103 which feeds the output amplifier IC309A. It is transformer coupled to the OUTPUT terminals and provides a low distortion, 1015 Hz, -40 to 0 dBm, 600 Ω test tone source for use in back-to-back and loop testing.

4.2.24 Power Supply (48-401 Board, PS-1A)

A dual tracking +15 and -15 V dc power supply is utilized in this instrument. It provides .01% line and .05% load regulation, and has a temperature coefficient of .02% per degree C. Noise and ripple on the power supply output are 4.0 millivolt rms maximum. Current capacity is 250 millamperes for each supply voltage. The unregulated 28 V dc power supply for the counter and indicator lamps is also provided by the power supply board.

The power supply is controlled by the front panel ON/OFF push switch S101. A 1/2 amp slow-blow fuse F101 is provided for protection of the line circuitry.

The power supply receives the low voltage ac from transformer T101. This transformer has a dual primary and is suitable for 115/230 V ac operation (optional). A center tapped secondary feeds the full wave rectifiers and filter capacitors for the dual 15 V supply. The Zener reference voltage from D405 is amplified by transistors Q405, Q408, which regulate the series pass transistor Q401. Current limiting is provided by Q404 and is set for 250 milliamps. Output voltage is controlled by R416. Additional filtering is provided by C407 and reverse voltage protection is provided by diode D403.

A similar arrangement is used in the +15 V regulated supply. This regulator obtains its reference voltage from the -15 V supply to provide tracking outputs.

The second winding of the power transformer provides the low voltage ac input to the unregulated, unfiltered 28 V supply. The transformer output is rectified by D402 and transient suppression is provided by C403. No additional filtering is required.

# 5. MAINTENANCE AND CALIBRATION

## 5.1 Maintenance Philisophy

Maintenance procedures for the Model 48 are divided into preventive and corrective classifications. Preventive maintenance consists of the routine performance checks which may be made using the front panel controls of the instrument. Corrective maintenance covers the symptom analysis, troubleshooting, repair and recalibration of the instrument.

## 5.2 Preventive Maintenance

### 5.2.1 General

The preventive maintenance procedures described in the following sections are used by the operator and maintenance personnel to verify proper instrument operation using the front panel controls. If proper operation is not achieved, see Section 5.3 for corrective maintenance procedures.

Periodic cleaning, lubrication or inspection of the Model 48 is not required.

All of the following checks are made using the 1015 HZ OUTPUT signal as an input. Connections between the OUTPUT and INPUT terminals may be made using clip leads or an appropriate test cord. The LEVEL SET control is adjusted in accordance with Section 3.3 for all of the following checks.

### 5.2.2 Input/Output Level Check

Place the meter switch in the OUTPUT LEVEL position and verify that the output level may be adjusted over a -20 to 0 dBm range. Set the OUTPUT LEVEL control at 0 dBm, and then monitor the input level. The reading should agree within ±0.5 dB of the output level reading.

Absolute calibration of the internal level meter may be checked by comparison with an external standard meter connected in parallel across the INPUT terminals.

### 5.2.3 Jitter Measurement Check

Verify that both the $3^{\circ}$ and $30^{\circ}$ P-P JITTER positions of the meter switch indicate less than $0.15^{\circ}$ and $1.5^{\circ}$ residual readings respectively. Change the INPUT switch between the BRIDGE and 900 Ω positions repeatedly on both ranges and verify that an upscale reading occurs during the switch transitions.

5.2.4 Phase Hit, Amplitude Hit, Coincidence Hit, and Dropout Check

Set the TIMER to HOLD, the phase hits PEAK DEGREES switch to 15°, and the amplitude hits ±DB switch to 6.

Remove the input signal (both leads must be removed simultaneously) and verify that one dropout and no phase hits, amplitude hits, or coincidence hits occur. When the input signal is reapplied, verify that there is a maximum of one phase hit, amplitude hit, and/or coincidence hit.

5.2.5 Caution Indicator Check

When the input signal is removed, verify that the CAUTION lamp lights either before or simultaneously with the DROPOUT indicator. When the input signal is reapplied, the CAUTION lamp will remain lit for a fraction of a second after the DROPOUT indicator has gone out.

5.3 Corrective Maintenance

5.3.1 Troubleshooting

This section covers symptom analysis, circuit level troubleshooting and calibration procedures for the Model 48.

No specialized mechanical assembly or disassembly procedures are required. Accepted practices should be followed when repair is undertaken on mainframe components or on printed circuit boards. Recommended troubleshooting techniques are based on signal tracing methods where a known input signal is used and the level and waveforms are verified as the signal progresses through the circuitry. Typical test equipment required to perform the troubleshooting procedures is listed in Table 5-1.

TABLE 5-1
MAINTENANCE TEST EQUIPMENT

| Description | Typical Model Number |
|---|---|
| Audio oscillator | HP 204C |
| Calibration test jig | See Section 5.3.4.5 |
| Ac Voltmeter | HP 400EL |
| Oscilloscope, single channel, 1 MHz frequency response | Tektronix 323 |
| Multitester | Simpson 260 |

5.3.2 Symptom Analysis

The preventive maintenance checks of Section 5.2 are used to isolate the area in which malfunction occurs. Table 5-2 summarizes possible fault locations for each of the preventive maintenance tests.

TABLE 5-2

SYMPTOM ANALYSIS

| Preventive Maintenance Test | Probable Trouble Locations |
|---|---|
| 1. No response from any test | a. Ac power cord<br>b. Fuse<br>c. Internal ac wiring or power switch S101<br>d. Power supply |
| 2. Input/Output Level Check | a. IC308, IC309A<br>b. Meter switch S102, meter level rectifiers D314, D315<br>c. Meter M101 |
| 3. Jitter measurement check | |
| Unable to LEVEL SET | a. IC201B, IC202<br>b. LEVEL SET control R120<br>c. T201 |
| No P-P JITTER reading | a. IC308 frequency incorrect<br>b. IC301B, IC302B, Q301, Q302, IC303, Q310, Q311, Q312<br>c. IC304, Q307, Q308<br>d. Meter switch S102 |
| 4. Hit Check | |
| 4.1 Phase Hits Check | a. IC305, IC306, Q309, Q213 thru Q218<br>b. 28 V dc supply, T101<br>c. Counter L102, COUNT/FLASH switch S106<br>d. PEAK DEGREES switch S103 |
| 4.2 Amplitude Hits Check | a. IC201A, IC203, IC204, IC205, IC206B, Q230 Q201 thru Q206<br>b. Counter L103, COUNT/FLASH switch S106<br>c. ±DB switch S104 |
| 4.3 Coincidence Hits Check | a. Q207 thru Q212, D209, D210<br>b. Counter L104<br>c. COUNT/FLASH switch S106 |
| 4.4 Dropout Check | |
| No counter operation<br>No light operation | a. IC206A, IC207, Q219 thru Q224<br>b. Q225, Q226 |
| 5. Caution Indicator Check | a. Q227, Q228, D213, D214 |
| 6. Power supply ±15 V dc | a. Transformer T101<br>b. Q401, Q402<br>c. Q403 thru Q408 |

### 5.3.3 Circuit Level Troubleshooting

The following sections describe the general procedures to be used in locating malfunctions. Where appropriate, performance standards, voltage levels, or waveform descriptions are provided to assist in the troubleshooting procedures. When a circuit has the proper input signal but the correct output cannot be measured, the components associated with that circuit should be checked and replaced if defective.

Before detailed troubleshooting is undertaken, the ±15 V power supply voltages should be checked. Low supply voltages may result from a malfunctioning power supply or excessive current being drawn by a defective circuit. A defective integrated circuit may often be located by feeling the case temperature. Normally, the integrated circuits are moderatley warm to the touch. However, when defective, they can become extremely warm, causing a painful sensation when touched.

#### 5.3.3.1 1015 Output Circuitry

The output oscillator is checked using an oscilloscope. Under normal operations, a 12 V p-p sinewave will be seen at terminals 300-2 and 300-Z, when the output LEVEL control R103 is fully clockwise. If no output is seen, check the oscillator circuit of IC308.

If the proper signal is present but no 1015 Hz output is seen, check amplifier IC309A and transformer T301. The output frequency may be verified using an electronic frequency counter connected directly across the TEST TONE OUTPUT terminals.

#### 5.3.3.2 Input Circuitry

The input circuitry is checked using a 0 dBm, 1015 Hz input signal.

Verify with an oscilloscope than an input signal with a level of approximately 0 dBm is present at the output of the first low pass filter stage IC202B Pin 7, and the output of the second low pass filter stage IC202B Pin 7. If 0 dBm cannot be obtained, check for input signals on both sides of the input transformer T201. With this input signal, verify that 0 dBm can be obtained at terminal 200-G by adjusting LEVEL SET control R120.

With the oscilloscope, verify that the output signal on terminal 200-G appears on terminal 300-D. Verify that a ±12 V or greater square wave at the test frequency is present at the output of the signal limiter IC301B Pin 12. This waveform is shown in Figure 5-1A. If this waveform is not seen, or if either peak voltage is less than 10 V, replace IC301 and retest.

The input level meter may be checked using the same input signal. The input-output level meter positions should read within ±0.5 dB of the standard level as measured by an external reference voltmeter. Calibration instructions are given in Section 5.3.4.2.

5.5.3.3 Phase Locked Oscillator

The phase locked oscillator incorporates the phase detector Q301, Q302, the low pass filter board (48-321), a reactance modulator Q310, Q311, Q312, oscillator IC307, and limiter IC302A.

With no input signal, check with an oscilloscope for a 10 V p-p or greater sinewave at Pin 1 of IC307A. If no signal is seen, check Q310, Q311, Q312, and their associated components. If this signal is present, verify that a ±12 V or greater square wave is present at the output of the reference limiter IC302A Pin 2. This waveform is shown in Figure 5-1A.

Connect a 1015 Hz test signal to the input, and adjust the instrument in accordance with Section 3.3. Verify that a ±6 V pulse train is present at the junction of R316, R317, and D306. When the CAUTION light is extinguished, the waveform has a frequency of twice the input frequency, i.e., 2030 Hz.

Place the instrument in an out of lock condition by changing the input frequency to 1100 Hz (CAUTION light on) and monitor the output waveform of the first phase jitter low pass filter section IC1B Pin 7 on the 48-321 board. This waveform is shown in Figure 5-1C, and will be a somewhat distorted isosceles wave varying at the difference frequency of the input test signal and the phase locked oscillator frequency.

Verify that a similar but inverted and smoother waveform is seen at the output of the second low pass filter stage IC1B Pin 1.

5.3.3.4 Peak-To-Peak Detector

The output of the low pass filter is ac-coupled to the high pass filter stage IC304B, and then through the BELL/BELL + LF switch to the p-p detector IC304A, Q307, Q308.

In the out-of-lock condition (input frequency or 1100 Hz), an isosceles waveform similar to that at IC18 Pin 1 should be seen at the high pass filter output IC304 Pin 7. It may have its peak clipped and will have an amplitude of approximately -12 V to +10 V.

With the meter switch in the LEVEL or FREQUENCY position, the dc voltage across the p-p detector capacitor C318 will vary from +2 to +5 V and from -2 to -5 V across C317.

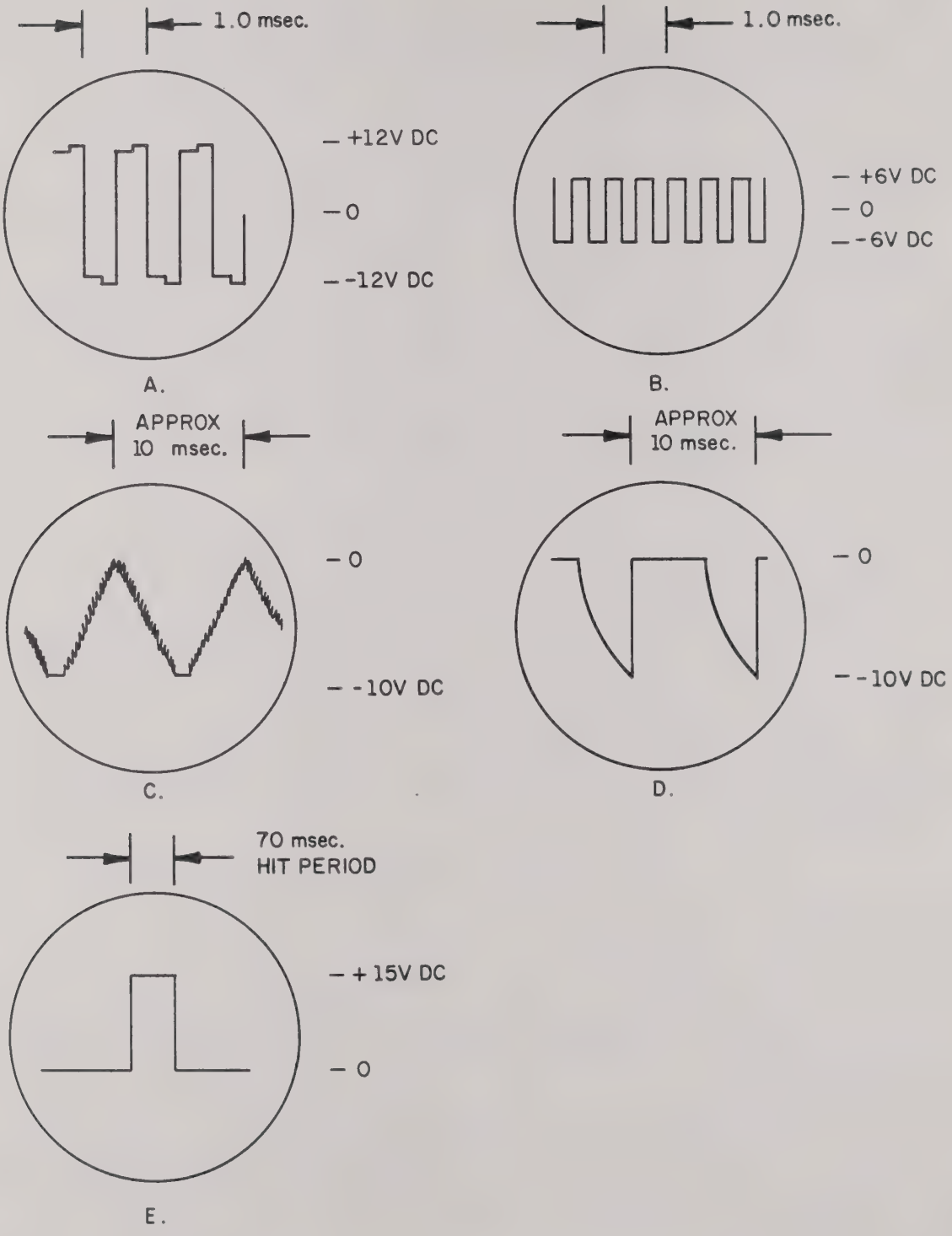



FIGURE 5-1. MODEL 48 WAVEFORMS

5.3.3.5 Phase Hits Detector

The phase hits detector takes the output of the low pass filter IC1A on the 48-321 board and full wave rectifies the signal in IC305. This rectified signal is then fed to a threshold detector IC306A whose threshold is set by the front panel PEAK DEGREES switch. The detector output is connected to the 4 millisecond hit delay circuit, consisting of Q309, IC306B.

In the out-of-lock condition (input frequency of 1100 Hz) and with the PEAK DEGREES switch in the 45° position, verify that a full wave rectified isosceles wave is seen at Pin 1 of the IC305A. It will have an approximate peak amplitude of +10 V.

The threshold detector IC306A should have a ±12 V nearly square wave output at Pin 2. If this waveform is not seen, carefully check the phase hits switch for dirty or bad contacts, and check IC306.

With the HIT DELAY switch in the IN position and using an oscilloscope, observe the waveform in the 4.0 msec hit delay circuitry at the junction of R384, C337, and D313. This waveform is shown in Figure 5-1D. When this waveform crosses the -7.5 V delay threshold level, the output of the hit delay detector IC306B will change from +12 to -12 V. Verify with an oscilloscope that this occurs.

5.3.3.6 Phase Hit Driver

The multivibrator circuit values are arranged to provide an "on" time of approximately 70 milliseconds followed by an "off" time of equal mimimum duration. The procedure of Section 5.3.3.10 may be used to troubleshoot the multivibrator and counter driver.

5.3.3.7 Out-of-Lock Detector

The out-of-lock detector compares the limited input signal with the limited 90° phase shifted reference oscillator signal from IC302B in the digital phase detector Q303, Q304.

The phase shifted reference oscillator output from IC302 Pin 12 should be a square wave with peaks at +12 and -12 V. In the out-of-lock condition, the voltage at the input of the out-of-lock detector IC301A Pin 5 should be negative. (Use an oscilloscope to observe.) In the locked condition, the voltage should be slightly positive. As this dc voltage goes from + to -, the output of the threshold detector IC301A Pin 2 should change from -12 V to +12 V as measured at terminal 300-H.

5.3.3.8 Amplitude Detector

The amplitude detector consists of a full wave rectifier IC201A, IC203A, followed by a 300 Hz low pass filter IC203B, IC204B. The input to the full wave rectifier is the same filtered input signal supplied to the phase jitter measurement circuitry.

With an input of 1015 Hz and a 0 dBm meter reading in the LEVEL SET position, a -1.8 V p full wave rectified 1015 Hz sinewave will be seen at the output of IC203A Pin 1. If measured with a dc meter, the voltage will be approximately -1 V. When the input signal is removed, the voltage at Pin 1 should be 0 ±0.1 V dc.

With approximately -1 V dc from the full wave rectifier, the output of the low pass filter IC204B Pin 7 will be -2 V dc. When the input signal is removed, this voltage should drop to 0 ±0.1 V dc.

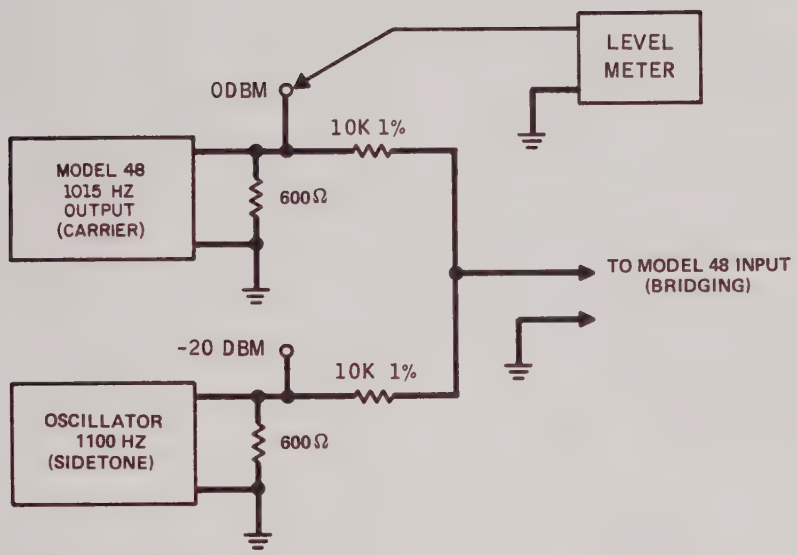
5.3.3.9 Amplitude Hits Detector

The amplitude hits detector consists of the reference amplifier IC204A, and the ± hit detectors IC205.

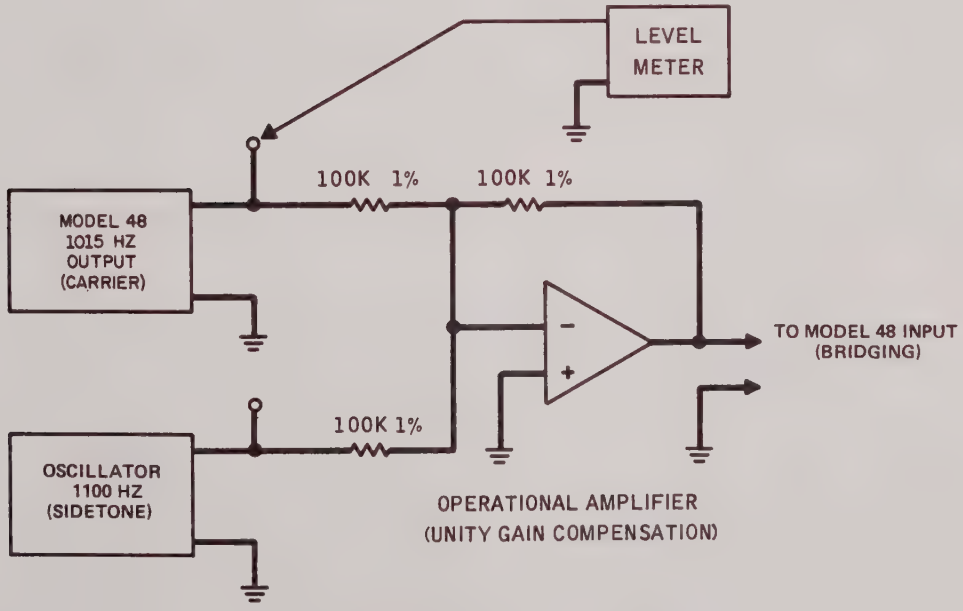
The -2 V dc output from the 300 Hz low pass filter is supplied to the reference amplifier through the integrating network R230, C223. This amplifier has a gain of 2 which results in an output voltage at Pin 1 (terminal 200-0) of -4 V dc. If this voltage is not apparent, it is likely that the ±DB switch or some of its associated resistors are defective. Verify that when the input signal is removed, the output voltage drops to - ±0.1 V dc. In the ±6 dB position of the amplitude hits switch, the voltages at terminals 200-K, 200-L, will be approximately -4 V dc and -1 V dc respectively. When no level changes are present, the outputs of the hit detectors IC205 Pins 12 and 2 will be -12 V dc. When amplitude hits are generated, the hit detector outputs will become +12 V dc during the hit detection. This may be verified with an oscilloscope using the test setup shown in Figure 5-2.

Set the SIDETONE LEVEL to -10.0 dBm ±0.1 dB. With the AMPLITUDE HITS switch set to ±1 dB verify that amplitude hits appear at IC205 Pins 2 and 12. Verify that these phase hits also appear at junction of D205, D206.

With the HIT DELAY switch in the IN position, use an oscilloscope to observe the waveform in the 4.0 msec hit delay circuitry at the junction of R240, C222, and D206. This waveform is similar to Figure 5-1D with a period of approximately 6 msec. When this waveform crosses the -7.5 V delay threshold level, the output of the hit detector IC206B will change from +12 to -12 V. Verify with an oscilloscope that this occurs.




A. RESISTOR TEST JIG (11.5° P-P JITTER ONLY)




B. OPERATIONAL AMPLIFIER TEST JIG

FIGURE 5-2. PHASE JITTER CALIBRATION TEST JIGS

5.3.3.10 Amplitude Hits Driver

The multivibrator provides an "on" time of approximately 70 milliseconds, followed by an "off" time having equal minimum duration. The following procedure may be used to troubleshoot all of the multivibrator/driver circuits.

The negative going hit signal is differentiated by C230 to provide a 15 V or greater trigger pulse across D216. This pulse triggers the multivibrator and results in a positive output pulse applied to the base of Q202. This results in a 0.7 V pulse at the base of Q201 which drives the appropriate indicator.

Multivibrator operation is clamped when a positive voltage is applied to the inhibit transistor Q206. During these periods, no signals will be seen at the base of Q205. The typical waveform across a driver output terminal during a hit is shown in Figure 5-1E.

5.3.3.11 Coincidence Detector

Coincidence between the phase and amplitude hits is detected by the diode "and" gate D209, D210. When a negative hit signal is present at both diode inputs, a negative signal is applied to the coincidence hits driver circuitry. The operation of this driver circuitry is identical to that described in Section 5.3.3.10. A test signal can be generated using a sidetone frequency of 1050 Hz ±2 Hz at a level of -10.0 dBm ±0.2 dB.

5.3.3.12 Dropout Detector

The level dropout detector consists of the threshold detector IC207 and the dropout timer IC206A, Q229.

A normal level input signal will result in a dc voltage of -2 V at the input of the threshold detector. This voltage will drop to near 0 V when the input signal is removed. When this voltage drops to below the reference voltage set by the dropout detector calibrate control R246, the dropout threshold detector output IC207B Pin 7 will change from -12 to +12 V. This change is used to drive the dropout timer which is similar to the hit delay circuit of Section 5.3.3.5, and results in an output signal from IC206A Pin 2 which changes from +12 to -12 V during a dropout condition. The dropout timer output is also applied to the Darlingtone pair transistors Q225, Q226 which drive the dropout indicator lamp.

5.3.3.13 Loss-of-Tone Detector (48-221 Board)

The input to the 48-220 board is connected to the input transformer on the 48-201 board. The input is then fed through an amplifier and comparator

made up of IC1 and IC2. The output of the comparator at Pin 13 of IC2 is then fed into an exclusive-OR gate made up of a portion of IC3. One input to the gate is delayed so that the output at Pin 10 of IC3 is a pulse of approximately 8 μs duration which occurs for each zero crossing of the input waveform. Each positive going pulse at Pin 10 of IC3 discharges C6 through Q1. Capacitor C6 will then recharge through resistor R13. When the voltage on C6 exceeds the threshold set at Pin 7 of comparator IC2, the output at Pin 1 of IC2 will go negative. This negative going transition at Pin 1 of IC2 discharges C8 through Q2. C8 then charges through resistor R19. When the voltage on C8 exceeds the threshold set at Pin 9 of comparator IC2, the output at Pin 14 of IC2 goes positive. The output at Pin 11 of IC3 is a positive pulse whose duration is approximately 100 μs for a normal 1 kHz input signal. The duration and position of this pulse is determined by the zero crossings of the input waveform and the time constants of C6, R13, and C8, R19. The zero crossing pulses at Pin 10 of IC3 and the pulse at Pin 11 of IC3 are then fed through an AND gate made up of diodes D2 and D4 and resistor R11. When consecutive zero crossing pulses occur between 440 and 550 μs, there will be a positive going pulse occurring at the base of Q3. This pulse will partially discharge C10 through Q3 and R31. The charge and discharge time constants of capacitor C10 and the threshold voltage at Pin 5 of comparator IC2 have been selected so that when the holding tone is lost or replaced by the band-limited white noise for a duration of 4 ms or longer, the output at Pin 2 of IC2 goes negative indicating a dropout condition. This signal is then fed to IC206 Pin 5 to operate the normal dropout circuitry.

5.3.3.14 Caution/Inhibit Circuitry (48-231 Board)

The caution/inhibit circuitry combines the dropout detector and out-of-lock detector outputs to illuminate the caution lamp and inhibit the hit counters whenever either condition exists.

When a dropout occurs, the 70 millisecond one-shot IC2B and the 140 millisecond one-shot IC2A are triggered. The output of the 140 millisecond one-shot is combined with the dropout and out-of-lock signals in OR gates IC1A, IC1C to provide a positive inhibit pulse. The duration of this pulse will be either 140 milliseconds or the duration of the dropout or the duration of the out-of lock condition, whichever is longer.

The output of the 70 millisecond one-shot is combined with the dropout signal in OR gate IC1A to illuminate the dropout lamp and control the dropout logic output. The output of IC2A is combined with the out-of-lock signal in OR gate IC2D to illuminate the caution lamp.

5.3.3.15 Power Supply

The power supply consists of a dual tracking ±15 V regulated supply and an unregulated 28 V supply.

The ac input for the regulated supply should be 32 V ac as measured from terminal A or B to ground with a multimeter. The rectified dc voltages across the filter capacitors C401, C402 should be ±32 V, respectively. If a proper negative output is measured, check the positive voltage regulator Q402, Q406, Q407. If neither supply voltage is proper, initially check the negative regulator Q401, Q405, Q408, which supplies the reference voltage to both regulators. If a defective regulator transistor is suspected and the heat sinks of either Q401 and Q402 are cool to the touch, replace that regulator transistor.

To verify that low voltage operation of the power supply is not the result of current limiting due to excessive load, temporarily disconnect the power supply leads from terminals G and I. Remeasure the supply voltages. If these are normal, use an ammeter to measure current output. This should not exceed 200 milliamps. Currents greater than that are the result of problems external to the power supply.

If Q401 and Q402 are found to be satisfactory, first replace Q404, Q405, Q408; then, if proper operation is not acheived, replace Q403, Q406, Q407.

Following transistor replacement, reset power supply voltages in accordance with Section 5.3.4.9.

The low voltage ac input to the unregulated 28 V supply should be 34 V ac as measured with a multimeter between terminals F and E. Dc output is 28 ±4 V dc and is measured between terminal D and ground. If the proper dc voltage is not obtained, check for shorts in external wiring and then replace D402.

5.3.4 Calibration

The following procedures are used to recalibrate the output signal frequency, the input/output level monitor meter, the phase locked oscillator/frequency meter scale, the p-p jitter ranges, the phase hits detector, the dropout detector and the out-of-lock detector. Recalibration is normally required when maintenance has been performed on associated circuitry or when there is a reason to suspect the calibration is no longer accurate.

5.3.4.1 Power Supply Voltage

Step 1. Connect an accurate dc voltmeter between terminals H and I of the power supply. Adjust R416 for -15.0 V.

Step 2. Move the dc voltmeter to terminals H and G and adjust R417 for an output of +15.0 V dc.

5.3.4.2 Test Tone Output Frequency

Step 1. Connect an electronic counter capable of measuring 1015 Hz to the OUTPUT terminals. Adjust the output LEVEL control until the counter is operating consistently. Adjust R361 to give an output frequency of 1015 ±1 Hz.

5.3.4.3 Input/Output Level Meter

Step 1. Connect the OUTPUT signal terminals to the INPUT terminals. Set the input switch to 600 Ω.

Step 2. Connect a standard reference meter in parallel with the INPUT terminals. Be sure all ground connections are properly made. Set the OUTPUT LEVEL to 0.0 dBm ±0.1 dB using the reference meter.

Step 3. Place the meter switch in the OUTPUT LEVEL position and adjust R393 for a meter reading of 0.0 dBm ±0.1 dB.

Step 4. Place the meter in the INPUT LEVEL position and adjust R209 to give a meter reading within ±0.1 dB of the reference meter.

5.3.4.4 Phase Locked Oscillator Frequency/Frequency Meter Scale

Step 1. Connect a 0.0 dBm ±0.1 dB test signal at a frequency of 1010 ±1 Hz to the INPUT terminals.

Step 2. Monitor Pin 1 of IC1 on the 48-321 board with digital voltmeter and adjust the phase locked oscillator frequency control R358 to give a reading of 0.0 V dc ±0.2 V dc on the voltmeter.

Step 3. Change the test signal to a frequency of 990 ±1 Hz. Place the meter switch in the FREQUENCY position.

Step 4. Adjust R7 on the 48-321 board for a meter reading of 990 Hz in the FREQUENCY position of the meter switch.

Step 5. Reset the input frequency to 1030 ±1 Hz and adjust R5 on the 48-321 board for a meter reading of 1030 Hz.

Step 6. Repeat Steps 3 thru 5 until the proper meter readings are obtained without further adjustment.

5.3.4.5 Peak-to-Peak Jitter

Step 1. The p-p jitter ranges are calibrated using a 2-tone audio technique where the phase jitter reading is proportional to the level difference between two input signals.

Step 2. To perform this calibration, two audio oscillators having 1% or less harmonic distortion are connected using the special test fixtures shown in Figure 5-2. A wide variety of integrated circuits or discrete operational amplifiers may be used in the test fixture, including the MC1437L and RC4558P used in the Model 48. Precision resistors of 1% tolerance are required in these networks. When external amplifier compensation is required, it should be provided for unity gain operation.

Step 3. Connect the oscillators as shown to the test fixture, and then connect the test fixture to the input of the Model 48. Set the carrier oscillator for a frequency of 1015 Hz (±2 Hz) and set its output level to 0.0 dBm ±0.1 dB.

Step 4. Adjust the frequency of the sidetone oscillator to 1100 Hz. The output level of this oscillator will be varied to obtain the desired phase jitter calibration levels.

Note: Caution must be used in calibrating these low values of phase jitter to ensure that no noise pickup, hum, etc., is introduced by the test fixture.

The carrier oscillator must have a low level of phase jitter in its output. This can be verified by the residual meter reading with the sidetone oscillator disconnected. If this reading is not below 0.15° p-p on the 3° range, the carrier oscillator should be replaced with an audio oscillator providing this residual reading. If this cannot be obtained, the OUTPUT oscillator of the Model 48 may be used as the carrier oscillator.

5.3.4.5a 30° Peak-to-Peak Jitter Range

Step 1. Adjust the LEVEL SET control for a 0 dBm reading in the LEVEL SET meter position.

Step 2. Adjust the sidetone oscillator for an output level of -20.0 dBm ±0.1 dB. This setting corresponds to a p-p jitter level of 11.5°.

Step 3. Set the BELL + LF/BELL switch to BELL and adjust R341 to give a reading of 11.5°.

Step 4. Set the BELL + LF/BELL switch to BELL + LF and adjust R907 on the BELL + LF board for a reading of 11.5° phase jitter.

Step 5. Set the sidetone frequency to 1018 Hz (3 Hz above carrier frequency) and adjust R905 for a reading of 10.8° phase jitter.

Step 6. Repeat above steps until no further adjustment is necessary.

Step 7. Set the BELL + LF/BELL switch to BELL.

5.3.4.5b 3° Peak-to-Peak Jitter Range

Step 1. Set the meter switch in the 3° P-P jitter range.

Step 2. Adjust the sidetone oscillator for a level of -41.2 dBm ±0.1 dB.

Step 3. Adjust the 3° calibration control R342 to give a reading of 1.0° ±0.1°.

5.3.4.6 Phase Hits Detector

Step 1. Calibration of the phase hits detector is made in a similar manner to that of the phase jitter calibration using the test fixtures of Figure 5-2.

Step 2. Repeat Steps 1 thru 4 of Section 5.3.4.5a.

Step 3. Place the PEAK DEGREE switch in the 15° position and place the timer in the HOLD position.

Step 4. Adjust the sidetone oscillator for a level of -14.2 dBm ±0.1 dB.

Step 5. Place the HIT DELAY switch in the OUT position, and place the FLASH/COUNT switch in the COUNT position.

Step 6. Adjust R388 so the PHASE HITS totalizer just begins to count with a steady rhythm. Verify that counter operation can be halted by a slight adjustment of R388, and then reset to the steady counting position.

Step 7. Set the HIT DELAY switch to the IN position.

5.3.4.7 Dropout Threshold

Step 1. Connect the OUTPUT signal terminals to the INPUT terminals.

Step 2. Set the meter switch to the INPUT position and adjust the test tone level control for 0.0 dBm ±0.1 dB.

Step 3. Set the meter switch to the LEVEL SET position and adjust the LEVEL SET control for 0.0 dBm ±0.1 dB.

Step 4. Without readjusting the LEVEL SET control, lower the input level 12.0 dBm ±0.1 dB. An external level meter should be used to obtain accurate readings of the output level.

Step 5. Adjust the dropout calibrate control R246 so that dropouts are continuously counted.

5.3.4.8 Out-of-Lock Detector

Step 1. Monitor the signal at the junction of R319 and R320 using an oscilloscope.

Step 2. Adjust the CAUTION FREQ control R320 for 7.5 V dc ±1.5 V dc as indicated on the oscilloscope.

TABLE 5-3

PHASE JITTER CALIBRATION CHART

| Sidetone Level | Peak-to-Peak Jitter | Application |
|---|---|---|
| -14.2 dB | $22.6^{\circ}$ | Phase hit calibration point ($15^{\circ}$ peak degrees) |
| -20.0 dB | $11.5^{\circ}$ | $30^{\circ}$ P-P JITTER range calibration point |
| -41.2 dB | $1.0^{\circ}$ | $3^{\circ}$ P-P JITTER range calibration point |

Note: Carrier oscillator is set at 0.0 dBm.

DOC #: ** MODEL ASSEMBLY INDEX ** DATE: 11/ 3/80
MODEL: 48 NAME: PHASE JITTER METER


| ASSEMBLY NO. | DESCRIPTION | PAGE | QUANTITY |
|---|---|---|---|
| D48-0 | CASE ASSY | 5-18 | 1 |
| D48-1 | UNIT ASSY | 5-19 | 1 |
| D48-1-0 | MECHANICAL ASSY | 5-20 | 1 |
| D48-1-1 | FRONT PANEL ASSY | 5-21 | 1 |
| D48-1-2 | POWER SUPPLY ASSY | 5-23 | 1 |
| D48-1-3 | LF JITTER ASSY | 5-24 | 1 |
| D48-1-4 | AMPLITUDE/HIT BD ASSY | 5-25 | 1 |
| D48-1-4-1 | INHIBIT BD ASSY | 5-29 | 1 |
| D48-1-4-2 | NOISE DROPOUT BD ASSY | 5-30 | 1 |
| D48-1-4-3 | CABLE ASSY | 5-32 | 1 |
| D48-1-5 | PHASE BD ASSY | 5-33 | 1 |
| D48-1-5-1 | FILTER BD ASSY | 5-36 | 1 |
| D48-1-5-2 | CABLE ASSY | 5-37 | 1 |
| D48-1-6 | CABLE ASSY | 5-38 | 1 |
| D48-2 | 19" RACK SHELF ADAPTER | 5-39 | |
| D48-3 | 23" RACK SHELF ADAPTER-12" HIGH | 5-40 | |
| D48-4 | 23" RACK SHELF ADAPTER-10.5" HIGH | 5-41 | |


------ END OF FILE -----

DOC NO: **PARTS LIST BY ASSEMBLY** DATE: 11/ 3/80
ASSEMBLY NO: D48-0
DESCRIPTION: CASE ASSY

| REF DES./QTY | STOCK NO. | DESCRIPTION |
|---|---|---|
| 2 | 23B00010 | FASTNER LID |
| 8 | 23E00003 | RUBBER FEET LARGE |
| 4 | 24A06004A | SCREW 6-32 X 1/4 BH-SL-SNP |
| 4 | 24A06005A | SCREW 6-32 X 5/16 BH-SL-SNP |
| 2 | 24A06006A | SCREW 6-32 X 3/8 BH-SL-SNP |
| 4 | 24A06008A | SCREW 6-32 X 1/2 BH-SL-SNP |
| 4 | 24A06102 | WASHER FLAT #6 SCP |
| 6 | 24A06104 | WASHER EXT TOOTH #6 |
| 4 | 24A06204 | NUT HEX 6 - 32 X 5/16 SNP |
| 8 | 24A08008A | SCREW 8-32 X 1/2 BH-SL-SNP |
| 8 | 24A08202 | LOCKING NUT NYLON INSERT 8-32 |
| 1 | F3901-030 | SERIAL NUMBER TAG |
| 2 | F48-16 | STOP |
| 1 | F48-18 | GASKET CASE |
| 1 | F48-19 | AC PAD |
| 1 | F48-13F | LID BRACKET AND HINGE ASSY |
| 1 | F48-14B | CASE MODIFICATION |
| 1 | F48-15B | PORTABLE LID ( 2 PIECES ) |
| 2 | F48-17C | PORTABLE MOUNTING BRACKET |
| | | |
| | | |
| | | ------ END OF FILE ----- |

DOC NO: **PARTS LIST BY ASSEMBLY** DATE: 11/ 3/80

ASSEMBLY NO: D48-1

DESCRIPTION: UNIT ASSEMBLY

| REF DES./QTY | STOCK NO. | DESCRIPTION |
|---|---|---|
| SUB | D48-1-0 | MECHANICAL ASSY |
| SUB | D48-1-1 | FRONT PANEL ASSY |
| SUB | D48-1-2 | POWER SUPPLY ASSY |
| SUB | D48-1-3 | LF JITTER ASSY |
| SUB | D48-1-4 | AMPLITUDE/HIT BD ASSY |
| SUB | D48-1-5 | PHASE BD ASSY |
| SUB | D48-1-6 | CABLE ASSY |
| | | UNIT ASSY |
| | | ------ END OF FILE ----- |

DOC NO:

**PARTS LIST BY ASSEMBLY**

DATE: 11/ 3/80

ASSEMBLY NO: D48-1-0

DESCRIPTION: MECHANICAL ASSY

| REF DES./QTY | STOCK NO. | DESCRIPTION |
|---|---|---|
| 2 | 11E00001 | LAMP 28V |
| 1 | 11E00003 | LAMP 28V |
| 1 | 16B00020 | TRANSFORMER POWER |
| 4 | 19A00003 | CONN COAX |
| 2 | 23D00031 | CLAMP CABLE |
| 2 | 23D00034 | CLAMP CABLE |
| 2 | 24A04006A | SCREW 4-40 X 3/8 BH-SL-SNP |
| 2 | 24A04102 | WASHER FLAT #4 SCP |
| 2 | 24A04104 | WASHER EXT TOOTH #4 |
| 3 | 24A06005A | SCREW 6-32 X 5/16 BH-SL-SNP |
| 13 | 24A06006C | SCREW 6-32 X 3/8 FH-SL-SNP |
| 2 | 24A06007A | SCREW 6-32 X 7/16 BH-SL-SNP |
| 1 | 24A06010A | SCREW 6-32 X 5/8 BH-SL-SNP |
| 2 | 24A06012A | SCREW 6-32 X 3/4 BH-SL-SNP |
| 8 | 24A06101 | WASHER FLAT #6 SNP |
| 25 | 24A06104 | WASHER EXT TOOTH #6 |
| 25 | 24A06204 | NUT HEX 6 - 32 X 5/16 SNP |
| 1 | 26A00002 | FUSE 1/2 AMP SB |
| 1 | F48-11 | CONECTOR BRACKET |
| 1 | F48-45B | SUPORT BRACKET WITH CLIPS |
| 3 | F48-5 | SUPORT BRACKET |
| 1 | F48-7 | BRACE |
| | | |
| | | ------ END OF FILE ----- |

DOC NO: **PARTS LIST BY ASSEMBLY** DATE: 11/ 3/80

ASSEMBLY NO: D48-1-1

DESCRIPTION: FRONT PANEL ASSY

| REF DES./QTY | STOCK NO. | DESCRIPTION |
|---|---|---|
| 2 | 01A11000A1 | CAP CER .01uF GMV 1.6KV |
| 6 | 11E00001 | LAMP 28V |
| 1 | 11E00003 | LAMP 28V |
| 1 | 12F01500 | RES METAL FILM 1.50K 1% 1/4W |
| 1 | 12F01740 | RES METAL FILM 1.74K 1% 1/4W |
| 9 | 12FD1500 | RES METAL FILM 150 OHM 1% 1/4W |
| 1 | 12FD2610 | RES METAL FILM 261 OHM 1% 1/4W |
| 1 | 12FD2940 | RES METAL FILM 294 OHM 1% 1/4W |
| 1 | 12FD4120 | RES METAL FILM 412 OHM 1% 1/4W |
| 1 | 12FD4640 | RES METAL FILM 464 OHM 1% 1/4W |
| 1 | 12FD6190 | RES METAL FILM 619 OHM 1% 1/4W |
| 1 | 12HD1370 | RES METAL FILM 137 OHM 1% 1W |
| 1 | 12HD6040 | RES METAL FILM 604 OHM 1% 1W |
| 1 | 12HD9090 | RES METAL FILM 909 OHM 1% 1W |
| 1 | 13B11000 | RES METAL FILM 10K 10% 2W 1 TURN |
| 1 | 13B11000A | RES CARBON 10K 10% .5W 1 TURN |
| 1 | 15B38000 | INDUCTOR CHOKE 8H -15 +50% |
| 4 | 19C00004 | CONN BINDING POST RED |
| 2 | 19C00008 | CONN BINDING POST BLACK |
| 4 | 19D00003 | CONN PHONE 3 CONTACT |
| 1 | 19M00001 | CONN POWER 3 CONTACT |
| 1 | 19Q00003 | CONN HAY RAKE 3 CONTACT |
| 1 | 19S00001 | CONN HARDWARE |
| 1 | 19S00002 | CONN HARDWARE |
| 4 | 19S00003 | CONN HARDWARE |
| 1 | 21B00003 | SWITCH ROTARY 3 POLE 2-3 POSITION |
| 1 | 21B00012 | SWITCH ROTARY 1 POLE 9 POSITION |
| 1 | 21B00013 | SWITCH ROTARY 2 POLE 4 POSITION |
| 1 | 21B00014 | SWITCH ROTARY 1 POLE 6 POSITION |
| 2 | 21B00015 | SWITCH ROTARY 3 POLE 4 POSITION |
| 1 | 21C00004 | SWITCH SLIDE 2 POLE 2 THROW |
| 1 | 21E00015 | SWITCH TOGGLE 3 POLE 2 THROW |
| 1 | 21E00018 | SWITCH TOGGLE 4 POLE 2 THROW |
| 1 | 21Z00003 | SWITCH ROCKER 2 POLE 2 THROW |
| 2 | 21Z00006 | SWITCH CAP WHITE |
| 1 | 22A00003 | METER 0-50UA |
| 4 | 22B00003 | COUNTER 24V |
| 1 | 22E00001 | TIMER 60 MIN W/HOLD |
| 2 | 23C00010 | KNOB 1/4 BLACK |
| 1 | 23C00011 | KNOB 1/8 |
| 1 | 23D00018 | HOLDER FUSE |
| 2 | 23D00031 | CLAMP CABLE |
| 1 | 23D00034 | CLAMP CABLE |
| 2 | 24A04003D | SET SCREW 4-40 X 3/16 BLK |
| 1 | 24A04005C | SCREW 4-40 X 5/16 FH-SL-SNP |
| 1 | 24A04104 | WASHER EXT TOOTH #4 |
| 1 | 24A04204 | NUT HEX 4 - 40 SNP |
| 2 | 24A06004C | SCREW 6-32 X 1/4 FH-SL-SNP |
| 4 | 24A06006C | SCREW 6-32 X 3/8 FH-SL-SNP |
| 2 | 24A06007C | SCREW 6-32 7/16 FH-SL-SNP |
| 1 | 24A06008C | SCREW 6-32 X 1/2 FH-SL-SNP |
| 5 | 24A06101 | WASHER FLAT #6 SNP |
| 1 | 24A06103 | WASHER SPLIT LOCK #6 |
| 8 | 24A06104 | WASHER EXT TOOTH #6 |

DOC NO: **PARTS LIST BY ASSEMBLY** DATE: 11/ 3/80

ASSEMBLY NO: D48-1-1

DESCRIPTION: FRONT PANEL ASSY

| REF DES./QTY | STOCK NO. | DESCRIPTION |
|---|---|---|
| 1 | 24A06203 | NUT HEX 6 - 32 X 1/4 SNP |
| 7 | 24A06204 | NUT HEX 6 - 32 X 5/16 SNP |
| 1 | 24C00010 | LUG SOLDER 1496 |
| 1 | 26A00002 | FUSE 1/2 AMP SB |
| 2 | 26D00001 | COMMUNICATIONS GAP |
| 1 | F48-8 | BRACKET SWITCH |
| 1 | F48-9 | SWITCH ADAPTER |
| 1 | F48-1 | FRONT PANNEL |
| 1 | F48-3 | RIGHT BRACKET |
| 1 | F48-4 | LEFT BRACKET |
| | | |
| | | |
| | | ------ END OF FILE ----- |

DOC NO: **PARTS LIST BY ASSEMBLY** DATE: 11/ 3/80
ASSEMBLY NO: D48-1-2
DESCRIPTION: POWER SUPPLY ASSY

| REF DES./QTY | STOCK NO. | DESCRIPTION |
|---|---|---|
| C401 | 01H53300 | CAP AL ELEC 330uF -10 +100% 35V |
| C402 | 01H53300 | CAP AL ELEC 330uF -10 +100% 35V |
| C403 | 01E22200 | CAP POLYCARB .22uF 5% 250V |
| C404 | 01A00200 | CAP CER 200PF 20% 1KV |
| C405 | 01A00200 | CAP CER 200PF 20% 1KV |
| C406 | 01H44700 | CAP AL ELEC 47uF -10 +100% 35V |
| C407 | 01H44700 | CAP AL ELEC 47uF -10 +100% 35V |
| D401 | 03J00001 | DIODE BRIDGE KBP04 400V 1.5A |
| D402 | 03J00001 | DIODE BRIDGE KBP04 400V 1.5A |
| D403 | 03E04004 | DIODE RECTIFIER 1N4004 400V 1A |
| D404 | 03E04004 | DIODE RECTIFIER 1N4004 400V 1A |
| D405 | 03C00751A | DIODE ZENER IN751A 5.1V 5% |
| D406 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D407 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D408 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D409 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D410 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| Q401 | 05B00014 | TRANSISTOR PNP 62204 |
| Q402 | 05B00014 | TRANSISTOR PNP 62204 |
| Q403 | 05A05138 | TRANSISTOR PNP 2N5138 |
| Q404 | 05C03566 | TRANSISTOR NPN 2N3566 |
| Q405 | 05C03566 | TRANSISTOR NPN 2N3566 |
| Q406 | 05C03566 | TRANSISTOR NPN 2N3566 |
| Q407 | 05C03566 | TRANSISTOR NPN 2N3566 |
| Q408 | 05A05138 | TRANSISTOR PNP 2N5138 |
| R401 | 12CB2400 | RES CARBON 2.4 OHM 5% 1/2W |
| R402 | 12CB2400 | RES CARBON 2.4 OHM 5% 1/2W |
| R403 | 12BC4700 | RES CARBON 47 OHM 5% 1/4W |
| R404 | 12BC4700 | RES CARBON 47 OHM 5% 1/4W |
| R405 | 12B01000 | RES CARBON 1K 5% 1/4W |
| R406 | 12B01000 | RES CARBON 1K 5% 1/4W |
| R407 | 12B01500 | RES CARBON 1.5K 5% 1/4W |
| R408 | 12B01500 | RES CARBON 1.5K 5% 1/4W |
| R409 | 12BD8200 | RES CARBON 820 OHM 5% 1/4W |
| R410 | 12B11500 | RES CARBON 15K 5% 1/4W |
| R411 | 12B12200 | RES CARBON 22K 5% 1/4W |
| R412 | 12B26800 | RES CARBON 680K 5% 1/4W |
| R413 | 12B11500 | RES CARBON 15K 5% 1/4W |
| R414 | 12F01000 | RES METAL FILM 1K 1% 1/4W |
| R415 | 12F01690 | RES METAL FILM 1.69K 1% 1/4W |
| R416 | 13A01000A1 | RES METAL FILM 1K 10% .5W 1 TURN |
| R417 | 13A01000A1 | RES METAL FILM 1K 10% .5W 1 TURN |
| R418 | 12F04750 | RES METAL FILM 4.75K 1% 1/4W |
| R419 | 12F05110 | RES METAL FILM 5.11K 1% 1/4W |
| 9 | 19R00003 | CONN TERMINAL |
| 4 | 24A04005A | SCREW 4-40 X 5/16 BH-SL-SNP |
| 3 | 24A04101 | WASHER FLAT #4 MS15795-803 |
| 3 | 24A04104 | WASHER EXT TOOTH #4 |
| 1 | 24C00006 | LUG 1416-6 |
| 1 | F44-037C | PS1-A D&T |
| REF | 44-049 | |
| REF | 44-050 | |
| | | ------ END OF FILE ----- |

DOC NO: **PARTS LIST BY ASSEMBLY** DATE: 11/ 3/90

ASSEMBLY NO: D48-1-3

DESCRIPTION: LF JITTER ASSY

| REF DES./QTY | STOCK NO. | DESCRIPTION |
|---|---|---|
| C901 | 01G32200 | CAP TANT ELEC 2.2uF 10% 20V |
| C902 | 01G32200 | CAP TANT ELEC 2.2uF 10% 20V |
| C903 | 01G42200 | CAP TANT ELEC 22uF 10% 15V |
| C905 | 01E24700 | CAP POLYCARB .47uF 5% 100V |
| C906 | 01H52200A | CAP AL ELEC 220uF -10 +50% 25V |
| C907 | 01H52200A | CAP AL ELEC 220uF -10 +50% 25V |
| IC1 | 08B04558 | IC OP AMP 4558 |
| IC2 | 08B04558 | IC OP AMP 4558 |
| R901 | 12F14530 | RES METAL FILM 45.3K 1% 1/4W |
| R902 | 12F14640 | RES METAL FILM 46.4K 1% 1/4W |
| R903 | 12B14300 | RES CARBON 43K 5% 1/4W |
| R904 | 12F05110 | RES METAL FILM 5.11K 1% 1/4W |
| R905 | 13A11000 | RES METAL FILM 10K 10% .5W 1 TURN |
| R906 | 12F22000 | RES METAL FILM 200K 1% 1/4W |
| R907 | 13A15000 | RES METAL FILM 50K 10% .5W 1 TURN |
| R908 | 12F21050 | RES METAL FILM 105K 1% 1/4W |
| R909 | 12B08200 | RES CARBON 8.2K 5% 1/4W |
| R910 | 12F15110 | RES METAL FILM 51.1K 1% 1/4W |
| R911 | 12F15110 | RES METAL FILM 51.1K 1% 1/4W |
| 8 | 19R00003 | CONN TERMINAL |
| 2 | 24A04005A | SCREW 4-40 X 5/16 BH-SL-SNP |
| 2 | 24A04102 | WASHER FLAT #4 SCP |
| 2 | 24A04104 | WASHER EXT TOOTH #4 |
| 1 | F48-402B | DRILL & TRIM |
| REF | B48-403 | |
| REF | B48-404 | |
| | | ------ END OF FILE ----- |

DOC NO: **PARTS LIST BY ASSEMBLY** DATE: 11/ 3/80

ASSEMBLY NO: D48-1-4

DESCRIPTION: AMPLITUDE/HIT BD ASSY

| REF DES./QTY | STOCK NO. | DESCRIPTION |
|---|---|---|
| C201 | 01F13900 | CAP POLYEST .039uF 5% 100V |
| C202 | 01F13900 | CAP POLYEST .039uF 5% 100V |
| C203 | 01D14700 | CAP POLYSTY .047uF 1% 33V |
| C204 | 01D12200 | CAP POLYSTY .022uF 1% 33V |
| C205 | 01D03300 | CAP POLYSTY 3300PF 1% 33V |
| C206 | 01E21000 | CAP POLYCARB .1uF 5% 250V |
| C207 | 01D16800 | CAP POLYSTY .068uF 1% 33V |
| C208 | 01D02700 | CAP POLYSTY 2700PF 1% 33V |
| C209 | 01E22200A | CAP POLYCARB .22uF 5% 100V |
| C210 | 01G42200 | CAP TANT ELEC 22uF 10% 15V |
| C211 | 01D13600 | CAP POLYSTY .036uF 1% 33V |
| C212 | 01D12000 | CAP POLYSTY .02uF 1% 33V |
| C213 | 01D03900 | CAP POLYSTY 3900PF 1% 33V |
| C214 | 01D11600 | CAP POLYSTY .016uF 1% 33V |
| C215 | 01D00910 | CAP POLYSTY 910PF 1% 33V |
| C216 | 01A00010 | CAP CER 10PF 0.5PF 1KV |
| C217 | 01A00010 | CAP CER 10PF 0.5PF 1KV |
| C218 | 01A00003 | CAP CER 3.3PF 0.5PF 1KV |
| C219 | 01A00003 | CAP CER 3.3PF 0.5PF 1KV |
| C220 | 01A00003 | CAP CER 3.3PF 0.5PF 1KV |
| C221 | 01A00010 | CAP CER 10PF 0.5PF 1KV |
| C222 | 01E22200A | CAP POLYCARB .22uF 5% 100V |
| C223 | 01G42200 | CAP TANT ELEC 22uF 10% 15V |
| C224 | 01G31000A | CAP TANT ELEC 1uF 10% 35V |
| C225 | 01A00010 | CAP CER 10PF 0.5PF 1KV |
| C226 | 01A00003 | CAP CER 3.3PF 0.5PF 1KV |
| C228 | 01A01000 | CAP CER 1000PF GMV 1KV |
| C229 | 01E22200A | CAP POLYCARB .22uF 5% 100V |
| C232 | 01A21000A | CAP CER .1uF 20% 20V |
| C233 | 01A21000A | CAP CER .1uF 20% 20V |
| C230A | 01A01000 | CAP CER 1000PF GMV 1KV |
| C230B | 01A01000 | CAP CER 1000PF GMV 1KV |
| C230C | 01A01000 | CAP CER 1000PF GMV 1KV |
| C231A | 01E22200A | CAP POLYCARB .22uF 5% 100V |
| C231B | 01E22200A | CAP POLYCARB .22uF 5% 100V |
| C231C | 01E22200A | CAP POLYCARB .22uF 5% 100V |
| D201 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D202 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D203 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D204 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D205 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D206 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D207 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D208 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D209 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D210 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D211 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D212 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D215 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D218 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D216A | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D216B | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D216C | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D217A | 03A03064 | DIODE SIGNAL 1N3064 75V |

DOC NO: **PARTS LIST BY ASSEMBLY** DATE: 11/ 3/80

ASSEMBLY NO: D48-1-4

DESCRIPTION: AMPLITUDE/HIT BD ASSY

| REF DES./QTY | STOCK NO. | DESCRIPTION |
|---|---|---|
| D217B | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D217C | 03A03064 | DIODE SIGNAL 1N3064 75V |
| IC201 | 08B04558 | IC OP AMP 4558 |
| IC202 | 08B04558 | IC OP AMP 4558 |
| IC203 | 08B04558 | IC OP AMP 4558 |
| IC204 | 08B04558 | IC OP AMP 4558 |
| IC205 | 08B01437 | IC OP AMP 1437 |
| IC206 | 08B01437 | IC OP AMP 1437 |
| IC207 | 08B04558 | IC OP AMP 4558 |
| Q201 | 05C03440 | TRANSISTOR NPN 2N3440 |
| Q202 | 05C04401 | TRANSISTOR NPN 2N4401 |
| Q203 | 05C04401 | TRANSISTOR NPN 2N4401 |
| Q204 | 05A04403 | TRANSISTOR PNP 2N4403 |
| Q205 | 05C04401 | TRANSISTOR NPN 2N4401 |
| Q206 | 05C04401 | TRANSISTOR NPN 2N4401 |
| Q207 | 05C03440 | TRANSISTOR NPN 2N3440 |
| Q208 | 05C04401 | TRANSISTOR NPN 2N4401 |
| Q209 | 05C04401 | TRANSISTOR NPN 2N4401 |
| Q210 | 05A04403 | TRANSISTOR PNP 2N4403 |
| Q211 | 05C04401 | TRANSISTOR NPN 2N4401 |
| Q212 | 05C04401 | TRANSISTOR NPN 2N4401 |
| Q213 | 05C03440 | TRANSISTOR NPN 2N3440 |
| Q214 | 05C04401 | TRANSISTOR NPN 2N4401 |
| Q215 | 05C04401 | TRANSISTOR NPN 2N4401 |
| Q216 | 05A04403 | TRANSISTOR PNP 2N4403 |
| Q217 | 05C04401 | TRANSISTOR NPN 2N4401 |
| Q218 | 05C04401 | TRANSISTOR NPN 2N4401 |
| Q219 | 05C03440 | TRANSISTOR NPN 2N3440 |
| Q220 | 05C04401 | TRANSISTOR NPN 2N4401 |
| Q221 | 05C04401 | TRANSISTOR NPN 2N4401 |
| Q222 | 05A04403 | TRANSISTOR PNP 2N4403 |
| Q223 | 05C04401 | TRANSISTOR NPN 2N4401 |
| Q224 | 05A04403 | TRANSISTOR PNP 2N4403 |
| Q225 | 05C04401 | TRANSISTOR NPN 2N4401 |
| Q226 | 05C03440 | TRANSISTOR NPN 2N3440 |
| Q227 | 05C04401 | TRANSISTOR NPN 2N4401 |
| Q228 | 05C03440 | TRANSISTOR NPN 2N3440 |
| Q229 | 05A04403 | TRANSISTOR PNP 2N4403 |
| Q230 | 05A04403 | TRANSISTOR PNP 2N4403 |
| R202 | 12F04020 | RES METAL FILM 4.02K 1% 1/4W |
| R203 | 12F08060 | RES METAL FILM 8.06K 1% 1/4W |
| R204 | 12F03480 | RES METAL FILM 3.48K 1% 1/4W |
| R205 | 12F12430 | RES METAL FILM 24.3K 1% 1/4W |
| R206 | 12F07320 | RES METAL FILM 7.32K 1% 1/4W |
| R207 | 12F04320 | RES METAL FILM 4.32K 1% 1/4W |
| R208 | 12F11050 | RES METAL FILM 10.5K 1% 1/4W |
| R209 | 13A05000 | RES METAL FILM 5K 10% .5W 1 TURN |
| R210 | 12B11000 | RES CARBON 10K 5% 1/4W |
| R211 | 12B02200 | RES CARBON 2.2K 5% 1/4W |
| R212 | 12BC2200 | RES CARBON 22 OHM 5% 1/4W |
| R213 | 12F12000 | RES METAL FILM 20K 1% 1/4W |
| R214 | 12F11000 | RES METAL FILM 10K 1% 1/4W |
| R215 | 12F11000 | RES METAL FILM 10K 1% 1/4W |
| R216 | 12F11000 | RES METAL FILM 10K 1% 1/4W |

| REF DES./QTY | STOCK NO. | DESCRIPTION |
|---|---|---|
| R217 | 12F11000 | RES METAL FILM 10K 1% 1/4W |
| R218 | 12B04700 | RES CARBON 4.7K 5% 1/4W |
| R219 | 12B04700 | RES CARBON 4.7K 5% 1/4W |
| R220 | 12F23160 | RES METAL FILM 316K 1% 1/4W |
| R221 | 12F11620 | RES METAL FILM 16.2K 1% 1/4W |
| R222 | 12F11620 | RES METAL FILM 16.2K 1% 1/4W |
| R223 | 12F09530 | RES METAL FILM 9.53K 1% 1/4W |
| R224 | 12F13240 | RES METAL FILM 32.4K 1% 1/4W |
| R225 | 12B12200 | RES CARBON 22K 5% 1/4W |
| R226 | 12F13160 | RES METAL FILM 31.6K 1% 1/4W |
| R227 | 12F16340 | RES METAL FILM 63.4K 1% 1/4W |
| R228 | 12F12150 | RES METAL FILM 21.5K 1% 1/4W |
| R229 | 12B14700 | RES CARBON 47K 5% 1/4W |
| R230 | 12B07500 | RES CARBON 7.5K 5% 1/4W |
| R231 | 12FD3650 | RES METAL FILM 365 OHM 1% 1/4W |
| R232 | 12FD3240 | RES METAL FILM 324 OHM 1% 1/4W |
| R233 | 12B04700 | RES CARBON 4.7K 5% 1/4W |
| R234 | 12B04700 | RES CARBON 4.7K 5% 1/4W |
| R235 | 12B32200 | RES CARBON 2.2M 5% 1/4W |
| R236 | 12B32200 | RES CARBON 2.2M 5% 1/4W |
| R237 | 12B04700 | RES CARBON 4.7K 5% 1/4W |
| R238 | 12B12200 | RES CARBON 22K 5% 1/4W |
| R239 | 12F11910 | RES METAL FILM 19.1K 1% 1/4W |
| R240 | 12BD1000 | RES CARBON 100 OHM 5% 1/4W |
| R241 | 12F11000 | RES METAL FILM 10K 1% 1/4W |
| R242 | 12F11000 | RES METAL FILM 10K 1% 1/4W |
| R243 | 12B21000 | RES CARBON 100K 5% 1/4W |
| R244 | 12B14700 | RES CARBON 47K 5% 1/4W |
| R245 | 12F12210 | RES METAL FILM 22.1K 1% 1/4W |
| R246 | 13A01000A | RES METAL FILM 1K 10% .5W 1 TURN |
| R247 | 12B01000 | RES CARBON 1K 5% 1/4W |
| R248 | 12B32200 | RES CARBON 2.2M 5% 1/4W |
| R249 | 12B02200 | RES CARBON 2.2K 5% 1/4W |
| R250 | 12B04700 | RES CARBON 4.7K 5% 1/4W |
| R251 | 12F03740 | RES METAL FILM 3.74K 1% 1/4W |
| R252 | 12BD1000 | RES CARBON 100 OHM 5% 1/4W |
| R253 | 12B21000 | RES CARBON 100K 5% 1/4W |
| R254 | 12F11000 | RES METAL FILM 10K 1% 1/4W |
| R255 | 12F11000 | RES METAL FILM 10K 1% 1/4W |
| R256 | 12B11000 | RES CARBON 10K 5% 1/4W |
| R257 | 12B11000 | RES CARBON 10K 5% 1/4W |
| R258 | 12B11000 | RES CARBON 10K 5% 1/4W |
| R261 | 12B13300 | RES CARBON 33K 5% 1/4W |
| R262 | 12B13300 | RES CARBON 33K 5% 1/4W |
| R263 | 12B04700 | RES CARBON 4.7K 5% 1/4W |
| R264 | 12B04700 | RES CARBON 4.7K 5% 1/4W |
| R265 | 12B04700 | RES CARBON 4.7K 5% 1/4W |
| R266 | 12B12200 | RES CARBON 22K 5% 1/4W |
| R267 | 12B12200 | RES CARBON 22K 5% 1/4W |
| R268 | 12B02200 | RES CARBON 2.2K 5% 1/4W |
| R271 | 12B22000 | RES CARBON 200K 5% 1/4W |
| R272 | 12B06800 | RES CARBON 6.8K 5% 1/4W |
| R273 | 12B04700 | RES CARBON 4.7K 5% 1/4W |
| R274 | 12B01000 | RES CARBON 1K 5% 1/4W |

DOC NO: **PARTS LIST BY ASSEMBLY** DATE: 11/ 3/80

ASSEMBLY NO: D48-1-4

DESCRIPTION: AMPLITUDE/HIT BD ASSY

| REF DES./QTY | STOCK NO. | DESCRIPTION |
|---|---|---|
| R275 | 12B14700 | RES CARBON 47K 5% 1/4W |
| R290 | 12B11000 | RES CARBON 10K 5% 1/4W |
| R276A | 12B21200 | RES CARBON 120K 5% 1/4W |
| R276B | 12B21200 | RES CARBON 120K 5% 1/4W |
| R276C | 12B21200 | RES CARBON 120K 5% 1/4W |
| R277A | 12B12200 | RES CARBON 22K 5% 1/4W |
| R277B | 12B12200 | RES CARBON 22K 5% 1/4W |
| R277C | 12B12200 | RES CARBON 22K 5% 1/4W |
| R278A | 12B12200 | RES CARBON 22K 5% 1/4W |
| R278B | 12B12200 | RES CARBON 22K 5% 1/4W |
| R278C | 12B12200 | RES CARBON 22K 5% 1/4W |
| R279A | 12B22000 | RES CARBON 200K 5% 1/4W |
| R279B | 12B22000 | RES CARBON 200K 5% 1/4W |
| R279C | 12B22000 | RES CARBON 200K 5% 1/4W |
| R280A | 12B06800 | RES CARBON 6.8K 5% 1/4W |
| R280B | 12B06800 | RES CARBON 6.8K 5% 1/4W |
| R280C | 12B06800 | RES CARBON 6.8K 5% 1/4W |
| R281A | 12B14700 | RES CARBON 47K 5% 1/4W |
| R281B | 12B14700 | RES CARBON 47K 5% 1/4W |
| R281C | 12B14700 | RES CARBON 47K 5% 1/4W |
| R282A | 12B14700 | RES CARBON 47K 5% 1/4W |
| R282B | 12B14700 | RES CARBON 47K 5% 1/4W |
| R282C | 12B14700 | RES CARBON 47K 5% 1/4W |
| R283A | 12B02200 | RES CARBON 2.2K 5% 1/4W |
| R283B | 12B02200 | RES CARBON 2.2K 5% 1/4W |
| R283C | 12B02200 | RES CARBON 2.2K 5% 1/4W |
| R284A | 12B04700 | RES CARBON 4.7K 5% 1/4W |
| R284B | 12B04700 | RES CARBON 4.7K 5% 1/4W |
| R284C | 12B04700 | RES CARBON 4.7K 5% 1/4W |
| R285A | 12B01000 | RES CARBON 1K 5% 1/4W |
| R285B | 12B01000 | RES CARBON 1K 5% 1/4W |
| R285C | 12B01000 | RES CARBON 1K 5% 1/4W |
| R286A | 12B11000 | RES CARBON 10K 5% 1/4W |
| R286B | 12B11000 | RES CARBON 10K 5% 1/4W |
| R286C | 12B11000 | RES CARBON 10K 5% 1/4W |
| R287A | 12B13300 | RES CARBON 33K 5% 1/4W |
| R287B | 12B13300 | RES CARBON 33K 5% 1/4W |
| R287C | 12B13300 | RES CARBON 33K 5% 1/4W |
| T1 | 16A00012 | TRANSFORMER SIGNAL |
| 30 | 19R00003 | CONN TERMINAL |
| 1 | 23H00013 | MU-METAL CAN |
| 6 | 23J00003 | INSULATOR TRANSISTOR TO-5 |
| 1 | F48-202G | DRILL & TRIM |
| SUB | D48-1-4-1 | INHIBIT BD ASSY |
| SUB | D48-1-4-2 | NOISE DROPOUT BD ASSY |
| SUB | D48-1-4-3 | CABLE ASSY |
| REF | C48-203-A | |
| REF | D48-204-A | |
| | | ------ END OF FILE ----- |

DOC NO: **PARTS LIST BY ASSEMBLY** DATE: 1/ 6/81

ASSEMBLY NO: D48-1-4-1 LAST REVISION:

DESCRIPTION: INHIBIT BD ASSY

| REF DES./QTY | STOCK NO. | DESCRIPTION |
|---|---|---|
| C1 | 01E24700 | CAP POLYCARB .47uF 5% 100V |
| C2 | 01E24700 | CAP POLYCARB .47uF 5% 100V |
| C3 | 01E24700 | CAP POLYCARB .47uF 5% 100V |
| C4 | 01A11000 | CAP CER .01uF 20% 50V |
| D1 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D2 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D3 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| IC1 | 07G04071 | IC CMOS 4071B |
| IC2 | 07G14538 | IC CMOS 14538B |
| Q1 | 05C04401 | TRANSISTOR NPN 2N4401 |
| R1 | 12B14700 | RES CARBON 47K 5% 1/4W |
| R2 | 12F23010 | RES METAL FILM 301K 1% 1/4W |
| R3 | 12F21540 | RES METAL FILM 154K 1% 1/4W |
| R4 | 12B13300 | RES CARBON 33K 5% 1/4W |
| R5 | 12B13300 | RES CARBON 33K 5% 1/4W |
| R6 | 12B13300 | RES CARBON 33K 5% 1/4W |
| R7 | 12B13300 | RES CARBON 33K 5% 1/4W |
| R8 | 12B13300 | RES CARBON 33K 5% 1/4W |
| R9 | 12B14700 | RES CARBON 47K 5% 1/4W |
| R10 | 12B14700 | RES CARBON 47K 5% 1/4W |
| 1 | 23A00074 | SPACER |
| 1 | F48-232 | INHIBIT BD DRILL & TRIM |
| REF | B48-233 | |
| REF | C48-234 | |
| | | ------ END OF FILE ----- |

DOC NO: **PARTS LIST BY ASSEMBLY** DATE: 1/ 6/81
ASSEMBLY NO: D48-1-4-2 LAST REVISION:
DESCRIPTION: NOISE DROPOUT BD ASSY

| REF DES./QTY | STOCK NO. | DESCRIPTION |
|---|---|---|
| C1 | 01A00470 | CAP CER 470PF 20% 1KV |
| C2 | 01G42200 | CAP TANT ELEC 22uF 10% 15V |
| C3 | 01G42200 | CAP TANT ELEC 22uF 10% 15V |
| C4 | 01G42200 | CAP TANT ELEC 22uF 10% 15V |
| C5 | 01B00120C | CAP MICA 120PF 5% 500V |
| C6 | 01D11000 | CAP POLYSTY .01uF 1% 33V |
| C7 | 01A01000 | CAP CER 1000PF GMV 1KV |
| C8 | 01D11000 | CAP POLYSTY .01uF 1% 33V |
| C9 | 01A01000 | CAP CER 1000PF GMV 1KV |
| C10 | 01D11000 | CAP POLYSTY .01uF 1% 33V |
| C11 | 01A11000 | CAP CER .01uF 20% 50V |
| D1 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D2 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D3 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D4 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D5 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D8 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D9 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D10 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| IC1 | 08B04558 | IC OP AMP 4558 |
| IC2 | 09C00339 | IC COMPARATOR 339 |
| IC3 | 07G04070 | IC CMOS 4070B |
| Q1 | 05C04401 | TRANSISTOR NPN 2N4401 |
| Q2 | 05A04403 | TRANSISTOR PNP 2N4403 |
| Q3 | 05C04401 | TRANSISTOR NPN 2N4401 |
| R1 | 12B11000 | RES CARBON 10K 5% 1/4W |
| R2 | 12B21000 | RES CARBON 100K 5% 1/4W |
| R3 | 12B01000 | RES CARBON 1K 5% 1/4W |
| R4 | 12B31000 | RES CARBON 1.0M 5% 1/4W |
| R5 | 12B11000 | RES CARBON 10K 5% 1/4W |
| R6 | 12BD1300 | RES CARBON 130 OHM 5% 1/4W |
| R7 | 12B21000 | RES CARBON 100K 5% 1/4W |
| R8 | 12B06200 | RES CARBON 6.2K 5% 1/4W |
| R9 | 12B11100 | RES CARBON 11K 5% 1/4W |
| R10 | 12F21000 | RES METAL FILM 100K 1% 1/4W |
| R11 | 12B13000 | RES CARBON 30K 5% 1/4W |
| R12 | 12B23000 | RES CARBON 300K 5% 1/4W |
| R13 | 12F16190 | RES METAL FILM 61.9K 1% 1/4W |
| R14 | 12F15110 | RES METAL FILM 51.1K 1% 1/4W |
| R15 | 12F15110 | RES METAL FILM 51.1K 1% 1/4W |
| R16 | 12B06200 | RES CARBON 6.2K 5% 1/4W |
| R17 | 12B11000 | RES CARBON 10K 5% 1/4W |
| R18 | 12B11600 | RES CARBON 16K 5% 1/4W |
| R19 | 12F11540 | RES METAL FILM 15.4K 1% 1/4W |
| R20 | 12F15110 | RES METAL FILM 51.1K 1% 1/4W |
| R21 | 12F15110 | RES METAL FILM 51.1K 1% 1/4W |
| R22 | 12B06200 | RES CARBON 6.2K 5% 1/4W |
| R23 | 12B21000 | RES CARBON 100K 5% 1/4W |
| R24 | 12B12200 | RES CARBON 22K 5% 1/4W |
| R25 | 12B06200 | RES CARBON 6.2K 5% 1/4W |
| R26 | 12B21000 | RES CARBON 100K 5% 1/4W |
| R28 | 12F04750 | RES METAL FILM 4.75K 1% 1/4W |
| R29 | 12F02940 | RES METAL FILM 2.94K 1% 1/4W |
| R31 | 12FD3650 | RES METAL FILM 365 OHM 1% 1/4W |

DOC NO: **PARTS LIST BY ASSEMBLY** DATE: 11/ 3/80
ASSEMBLY NO: D48-1-4-2
DESCRIPTION: NOISE DROPOUT BD ASSY

| REF DES./QTY | STOCK NO. | DESCRIPTION |
|---|---|---|
| R32 | 12F28060 | RES METAL FILM 806K 1% 1/4W |
| R33 | 12B23000 | RES CARBON 300K 5% 1/4W |
| 5 | 19R00004 | CONN TERMINAL |
| 2 | 23A00074 | SPACER |
| 1 | F48-222B | DRILL & TRIM |
| REF | A-B48-223 | |
| REF | C48-224 | |
| | | ------ END OF FILE ----- |

DOC NO:

**PARTS LIST BY ASSEMBLY**

DATE: 11/ 3/80

ASSEMBLY NO: D48-1-4-3
DESCRIPTION: CABLE ASSY

| REF DES./QTY | STOCK NO. | DESCRIPTION |
|---|---|---|
| 1 | F48-43 | HARNESS LAYOUT 231BOARD |
| | | ------ END OF FILE ----- |

DOC NO: **PARTS LIST BY ASSEMBLY** DATE: 11/ 3/80
ASSEMBLY NO: D48-1-5
DESCRIPTION: PHASE BD ASSY

| REF DES./QTY | STOCK NO. | DESCRIPTION |
|---|---|---|
| C301 | 01A00003 | CAP CER 3.3PF 0.5PF 1KV |
| C302 | 01A00003 | CAP CER 3.3PF 0.5PF 1KV |
| C303 | 01A00010 | CAP CER 10PF 0.5PF 1KV |
| C304 | 01A00010 | CAP CER 10PF 0.5PF 1KV |
| C305 | 01A00010 | CAP CER 10PF 0.5PF 1KV |
| C306 | 01A00003 | CAP CER 3.3PF 0.5PF 1KV |
| C307 | 01G32200 | CAP TANT ELEC 2.2uF 10% 20V |
| C308 | 01D11300 | CAP POLYSTY .013uF 1% 33V |
| C314 | 01E24700 | CAP POLYCARB .47uF 5% 100V |
| C315 | 01E24700 | CAP POLYCARB .47uF 5% 100V |
| C317 | 01G42200 | CAP TANT ELEC 22uF 10% 15V |
| C318 | 01G42200 | CAP TANT ELEC 22uF 10% 15V |
| C320 | 01B00390C | CAP MICA 390PF 5% 500V |
| C321 | 01D21000 | CAP POLYSTY .1uF 1% 33V |
| C322 | 01D21000 | CAP POLYSTY .1uF 1% 33V |
| C323 | 01A00010 | CAP CER 10PF 0.5PF 1KV |
| C324 | 01A00010 | CAP CER 10PF 0.5PF 1KV |
| C325 | 01A11000 | CAP CER .01uF 20% 50V |
| C326 | 01D11000 | CAP POLYSTY .01uF 1% 33V |
| C327 | 01F35000 | CAP POLYEST 5uF 5% 200V |
| C328 | 01D11000 | CAP POLYSTY .01uF 1% 33V |
| C331 | 01A21000A | CAP CER .1uF 20% 20V |
| C332 | 01A21000A | CAP CER .1uF 20% 20V |
| C333 | 01A00047 | CAP CER 47PF 20% 1KV |
| C334 | 01A00047 | CAP CER 47PF 20% 1KV |
| C335 | 01A00047 | CAP CER 47PF 20% 1KV |
| C336 | 01A00047 | CAP CER 47PF 20% 1KV |
| C337 | 01E22200A | CAP POLYCARB .22uF 5% 100V |
| C338 | 01E22200A | CAP POLYCARB .22uF 5% 100V |
| C339 | 01H44700 | CAP AL ELEC 47uF -10 +100% 35V |
| C340 | 01E22200A | CAP POLYCARB .22uF 5% 100V |
| C908 | 01H53300 | CAP AL ELEC 330uF -10 +100% 35V |
| D301 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D302 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D303 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D304 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D305 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D306 | 03C00706A | DIODE ZENER 1N706A 6.1V 5% |
| D307 | 03C00706A | DIODE ZENER 1N706A 6.1V 5% |
| D308 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D309 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D310 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D311 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D312 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D313 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D314 | 04A00191 | DIODE SIGNAL 1N191 90V |
| D315 | 04A00191 | DIODE SIGNAL 1N191 90V |
| D316 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D317 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| IC301 | 08B01437 | IC OP AMP 1437 |
| IC302 | 08B01437 | IC OP AMP 1437 |
| IC304 | 08B04558 | IC OP AMP 4558 |
| IC305 | 08B04558 | IC OP AMP 4558 |
| IC306 | 08B01437 | IC OP AMP 1437 |

| REF DES./QTY | STOCK NO. | DESCRIPTION |
|---|---|---|
| IC307 | 08B04558 | IC OP AMP 4558 |
| IC308 | 08B04558 | IC OP AMP 4558 |
| IC309 | 08B04558 | IC OP AMP 4558 |
| Q301 | 05C04401 | TRANSISTOR NPN 2N4401 |
| Q302 | 05C04401 | TRANSISTOR NPN 2N4401 |
| Q303 | 05C04401 | TRANSISTOR NPN 2N4401 |
| Q304 | 05C04401 | TRANSISTOR NPN 2N4401 |
| Q307 | 05C04401 | TRANSISTOR NPN 2N4401 |
| Q308 | 05A04403 | TRANSISTOR PNP 2N4403 |
| Q309 | 05A04403 | TRANSISTOR PNP 2N4403 |
| Q310 | 05A04403 | TRANSISTOR PNP 2N4403 |
| Q311 | 05C04401 | TRANSISTOR NPN 2N4401 |
| Q312 | 05C04401 | TRANSISTOR NPN 2N4401 |
| R301 | 12B11000 | RES CARBON 10K 5% 1/4W |
| R302 | 12B11000 | RES CARBON 10K 5% 1/4W |
| R303 | 12B11000 | RES CARBON 10K 5% 1/4W |
| R304 | 12B11000 | RES CARBON 10K 5% 1/4W |
| R305 | 12B12200 | RES CARBON 22K 5% 1/4W |
| R306 | 12B21000 | RES CARBON 100K 5% 1/4W |
| R307 | 12B21000 | RES CARBON 100K 5% 1/4W |
| R308 | 12B21000 | RES CARBON 100K 5% 1/4W |
| R309 | 12B21000 | RES CARBON 100K 5% 1/4W |
| R310 | 12B21000 | RES CARBON 100K 5% 1/4W |
| R311 | 12B21000 | RES CARBON 100K 5% 1/4W |
| R312 | 12B11000 | RES CARBON 10K 5% 1/4W |
| R313 | 12B11000 | RES CARBON 10K 5% 1/4W |
| R314 | 12B11000 | RES CARBON 10K 5% 1/4W |
| R315 | 12B11000 | RES CARBON 10K 5% 1/4W |
| R316 | 12B12200 | RES CARBON 22K 5% 1/4W |
| R317 | 12B02200 | RES CARBON 2.2K 5% 1/4W |
| R318 | 12B22200 | RES CARBON 220K 5% 1/4W |
| R319 | 12B22200 | RES CARBON 220K 5% 1/4W |
| R320 | 13A12000 | RES METAL FILM 20K 10% .75W 15 TURN |
| R321 | 12B01000 | RES CARBON 1K 5% 1/4W |
| R322 | 12B21000 | RES CARBON 100K 5% 1/4W |
| R326 | 12B11000 | RES CARBON 10K 5% 1/4W |
| R335 | 12F12740 | RES METAL FILM 27.4K 1% 1/4W |
| R336 | 12B12200 | RES CARBON 22K 5% 1/4W |
| R337 | 12F13160 | RES METAL FILM 31.6K 1% 1/4W |
| R339 | 12F11000 | RES METAL FILM 10K 1% 1/4W |
| R340 | 12B04700 | RES CARBON 4.7K 5% 1/4W |
| R341 | 13A12000 | RES METAL FILM 20K 10% .75W 15 TURN |
| R342 | 13A12000 | RES METAL FILM 20K 10% .75W 15 TURN |
| R343 | 12B21000 | RES CARBON 100K 5% 1/4W |
| R344 | 12B21000 | RES CARBON 100K 5% 1/4W |
| R345 | 12F16190 | RES METAL FILM 61.9K 1% 1/4W |
| R346 | 12F14530 | RES METAL FILM 45.3K 1% 1/4W |
| R348 | 12F11820 | RES METAL FILM 18.2K 1% 1/4W |
| R349 | 12B11000 | RES CARBON 10K 5% 1/4W |
| R350 | 12B11000 | RES CARBON 10K 5% 1/4W |
| R351 | 12F15110 | RES METAL FILM 51.1K 1% 1/4W |
| R352 | 12F22550 | RES METAL FILM 255K 1% 1/4W |
| R353 | 12F21820 | RES METAL FILM 182K 1% 1/4W |
| R354 | 12F31000 | RES METAL FILM 1M 1% 1/4W |

DOC NO: **PARTS LIST BY ASSEMBLY** DATE: 11/ 3/80

ASSEMBLY NO: D48-1-5

DESCRIPTION: PHASE BD ASSY

| REF DES./QTY | STOCK NO. | DESCRIPTION |
|---|---|---|
| R355 | 12F11000 | RES METAL FILM 10K 1% 1/4W |
| R356 | 12F13160 | RES METAL FILM 31.6K 1% 1/4W |
| R357 | 12FC8660 | RES METAL FILM 86.6 OHM 1% 1/4W |
| R358 | 13AD5000A | RES METAL FILM 500 OHM 10% .75W 15 T |
| R359 | 12B11000 | RES CARBON 10K 5% 1/4W |
| R360 | 12F11470 | RES METAL FILM 14.7K 1% 1/4W |
| R361 | 13A02000 | RES METAL FILM 2K 10% .5W 1 TURN |
| R362 | 12F11000 | RES METAL FILM 10K 1% 1/4W |
| R363 | 12F11000 | RES METAL FILM 10K 1% 1/4W |
| R364 | 12F11540 | RES METAL FILM 15.4K 1% 1/4W |
| R365 | 12B12700 | RES CARBON 27K 5% 1/4W |
| R366 | 12B31100 | RES CARBON 1.1M 5% 1/4W |
| R367 | 12B11000 | RES CARBON 10K 5% 1/4W |
| R368 | 12B12400 | RES CARBON 24K 5% 1/4W |
| R369 | 12FD6190 | RES METAL FILM 619 OHM 1% 1/4W |
| R370 | 12F01620 | RES METAL FILM 1.62K 1% 1/4W |
| R372 | 12F11000 | RES METAL FILM 10K 1% 1/4W |
| R373 | 12F11000 | RES METAL FILM 10K 1% 1/4W |
| R374 | 12F11000 | RES METAL FILM 10K 1% 1/4W |
| R376 | 12F11690 | RES METAL FILM 16.9K 1% 1/4W |
| R377 | 12B04700 | RES CARBON 4.7K 5% 1/4W |
| R378 | 12B04700 | RES CARBON 4.7K 5% 1/4W |
| R379 | 12B11000 | RES CARBON 10K 5% 1/4W |
| R380 | 12B01000 | RES CARBON 1K 5% 1/4W |
| R381 | 12B21000 | RES CARBON 100K 5% 1/4W |
| R382 | 12B12200 | RES CARBON 22K 5% 1/4W |
| R383 | 12F11910 | RES METAL FILM 19.1K 1% 1/4W |
| R384 | 12BD1000 | RES CARBON 100 OHM 5% 1/4W |
| R385 | 12F11000 | RES METAL FILM 10K 1% 1/4W |
| R386 | 12F11000 | RES METAL FILM 10K 1% 1/4W |
| R387 | 12F11000 | RES METAL FILM 10K 1% 1/4W |
| R388 | 13A01000A2 | RES METAL FILM 1K 10% .75W 15 TURN |
| R389 | 12F01620 | RES METAL FILM 1.62K 1% 1/4W |
| R390 | 12F11000 | RES METAL FILM 10K 1% 1/4W |
| R391 | 12F11000 | RES METAL FILM 10K 1% 1/4W |
| R393 | 12F11150 | RES METAL FILM 11.5K 1% 1/4W |
| R394 | 12F09090 | RES METAL FILM 9.09K 1% 1/4W |
| R395 | 13A02000 | RES METAL FILM 2K 10% .5W 1 TURN |
| T301 | 16A00016 | TRANSFORMER SIGNAL 600:600 |
| 33 | 19R00003 | CONN TERMINAL |
| 1 | F48-302L | DRILL & TRIM |
| SUB | D48-1-5-1 | FILTER BD ASSY |
| SUB | D48-1-5-2 | CABLE ASSY |
| REF | C48-303A | |
| REF | D48-304A-1 | |
| | | ------ END OF FILE ----- |

DOC NO: **PARTS LIST BY ASSEMBLY** DATE: 11/ 3/80

ASSEMBLY NO: D48-1-5-1

DESCRIPTION: FILTER BD ASSY

| REF DES./QTY | STOCK NO. | DESCRIPTION |
|---|---|---|
| C1 | 01A11000 | CAP CER .01uF 20% 50V |
| C2 | 01E24700 | CAP POLYCARB .47uF 5% 100V |
| C3 | 01D01200 | CAP POLYSTY 1200PF 1% 33V |
| C4 | 01D01600 | CAP POLYSTY 1600PF 1% 33V |
| C5 | 01D12700 | CAP POLYSTY .027uF 1% 33V |
| C6 | 01D14700 | CAP POLYSTY .047uF 1% 33V |
| C7 | 01E22200A | CAP POLYCARB .22uF 5% 100V |
| C8 | 01D00680 | CAP POLYSTY 680PF 1% 33V |
| C9 | 01D11900A | CAP POLYSTY .019uF 2.5% 33V |
| C10 | 01D11500 | CAP POLYSTY .015uF 1% 33V |
| C11 | 01E21000 | CAP POLYCARB .1uF 5% 250V |
| C12 | 01E21000 | CAP POLYCARB .1uF 5% 250V |
| C13 | 01D03600 | CAP POLYSTY 3600PF 1% 33V |
| D1 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| D2 | 03A03064 | DIODE SIGNAL 1N3064 75V |
| IC1 | 08B04558 | IC OP AMP 4558 |
| IC2 | 08B04558 | IC OP AMP 4558 |
| IC3 | 07G04013 | IC CMOS 4013B |
| Q1 | 05E05639 | TRANSISTOR JFET 2N5639 |
| R1 | 12B13300 | RES CARBON 33K 5% 1/4W |
| R2 | 12B13300 | RES CARBON 33K 5% 1/4W |
| R3 | 12B11100 | RES CARBON 11K 5% 1/4W |
| R4 | 12F23830 | RES METAL FILM 383K 1% 1/4W |
| R5 | 13A15000 | RES METAL FILM 50K 10% .5W 1 TURN |
| R6 | 12BD1000 | RES CARBON 100 OHM 5% 1/4W |
| R7 | 13A12000A | RES METAL FILM 20K 10% .5W 1 TURN |
| R8 | 12F02490 | RES METAL FILM 2.49K 1% 1/4W |
| R9 | 12F21050 | RES METAL FILM 105K 1% 1/4W |
| R10 | 12F21050 | RES METAL FILM 105K 1% 1/4W |
| R11 | 12F21050 | RES METAL FILM 105K 1% 1/4W |
| R12 | 12F21050 | RES METAL FILM 105K 1% 1/4W |
| R13 | 12F14640 | RES METAL FILM 46.4K 1% 1/4W |
| R14 | 12F15110 | RES METAL FILM 51.1K 1% 1/4W |
| R15 | 12F12550 | RES METAL FILM 25.5K 1% 1/4W |
| R16 | 12F13010 | RES METAL FILM 30.1K 1% 1/4W |
| R17 | 12F11300 | RES METAL FILM 13K 1% 1/4W |
| R18 | 12F11740 | RES METAL FILM 17.4K 1% 1/4W |
| R19 | 12F11740 | RES METAL FILM 17.4K 1% 1/4W |
| R20 | 12F12210 | RES METAL FILM 22.1K 1% 1/4W |
| R21 | 12F13320 | RES METAL FILM 33.2K 1% 1/4W |
| R22 | 12F12670 | RES METAL FILM 26.7K 1% 1/4W |
| R23 | 12F21330 | RES METAL FILM 133K 1% 1/4W |
| R24 | 12F11000 | RES METAL FILM 10K 1% 1/4W |
| R25 | 12F12000 | RES METAL FILM 20K 1% 1/4W |
| R26 | 12B21000 | RES CARBON 100K 5% 1/4W |
| 1 | 23A00074 | SPACER |
| 1 | 24A04005A | SCREW 4-40 X 5/16 BH-SL-SNP |
| 1 | 24A04104 | WASHER EXT TOOTH #4 |
| 1 | F48-322-1 | DRILL & TRIM |
| REF | B48-323 | |
| REF | C48-324 | |
| | | ------ END OF FILE ----- |

DOC NO: **PARTS LIST BY ASSEMBLY** DATE: 11/ 3/80
ASSEMBLY NO: D48-1-5-2
DESCRIPTION: CABLE ASSY

| REF DES./QTY | STOCK NO. | DESCRIPTION |
|---|---|---|
| 1 | F48-43 | HARNESS LAYOUT 2318OARD |
| | | ------ END OF FILE ----- |

DOC NO: **PARTS LIST BY ASSEMBLY** DATE: 11/ 3/80
ASSEMBLY NO: D48-1-6
DESCRIPTION: CABLE ASSY

| REF DES./QTY | STOCK NO. | DESCRIPTION |
|---|---|---|
| 1 | F48-33 | SIGNAL HARNESS |
| | | ------ END OF FILE ----- |

DOC NO: **PARTS LIST BY ASSEMBLY** DATE: 11/ 3/80
ASSEMBLY NO: D48-2
DESCRIPTION: 19" RACK SHELF ADAPTER

| REF DES./QTY | STOCK NO. | DESCRIPTION |
|---|---|---|
| 1 | F48-60 | SHELF PANEL 19" |
| 1 | F48-62 | SHELF SUPPORT 19" |
| 1 | F48-63 | RACK SHELF STENCIL |
| 1 | F48-64-1 | SHELF BRACKET - FRONT |
| 1 | F48-64-2 | SHELF BRACKET - REAR |
| REF | D48-67 | 19" RACK ADAPTER ASSEMBLY |
| | | ------ END OF FILE ----- |

DOC NO: **PARTS LIST BY ASSEMBLY** DATE: 11/ 3/80
ASSEMBLY NO: D48-3
DESCRIPTION: 23" RACK SHELF ADAPTER-12" HIGH

| REF DES./QTY | STOCK NO. | DESCRIPTION |
|---|---|---|
| 1 | F48-62 | SHELF SUPPORT 19" |
| 1 | F48-63 | RACK SHELF STENCIL |
| 1 | F48-64-1 | SHELF BRACKET - FRONT |
| 1 | F48-64-2 | SHELF BRACKET - REAR |
| 1 | F48-65 | SHELF PANEL 23" X 12" |
| REF | D48-68 | 23 X 12 RACK ADPT ASSY |
| | | ------ END OF FILE ----- |

DOC NO: **PARTS LIST BY ASSEMBLY** DATE: 11/ 3/80

ASSEMBLY NO: D48-4

DESCRIPTION: 23" RACK SHELF ADAPTER-10.5" HIGH

| REF DES./QTY | STOCK NO. | DESCRIPTION |
|---|---|---|
| 1 | F48-62 | SHELF SUPPORT 19" |
| 1 | F48-63 | RACK SHELF STENCIL |
| 1 | F48-64-1 | SHELF BRACKET - FRONT |
| 1 | F48-64-2 | SHELF BRACKET - REAR |
| 1 | F48-66 | SHELF PANEL 23" X 10.5" |
| REF | D48-69 | 23 X 10.5 RACK ADPT ASSY |
| | | ------ END OF FILE ----- |

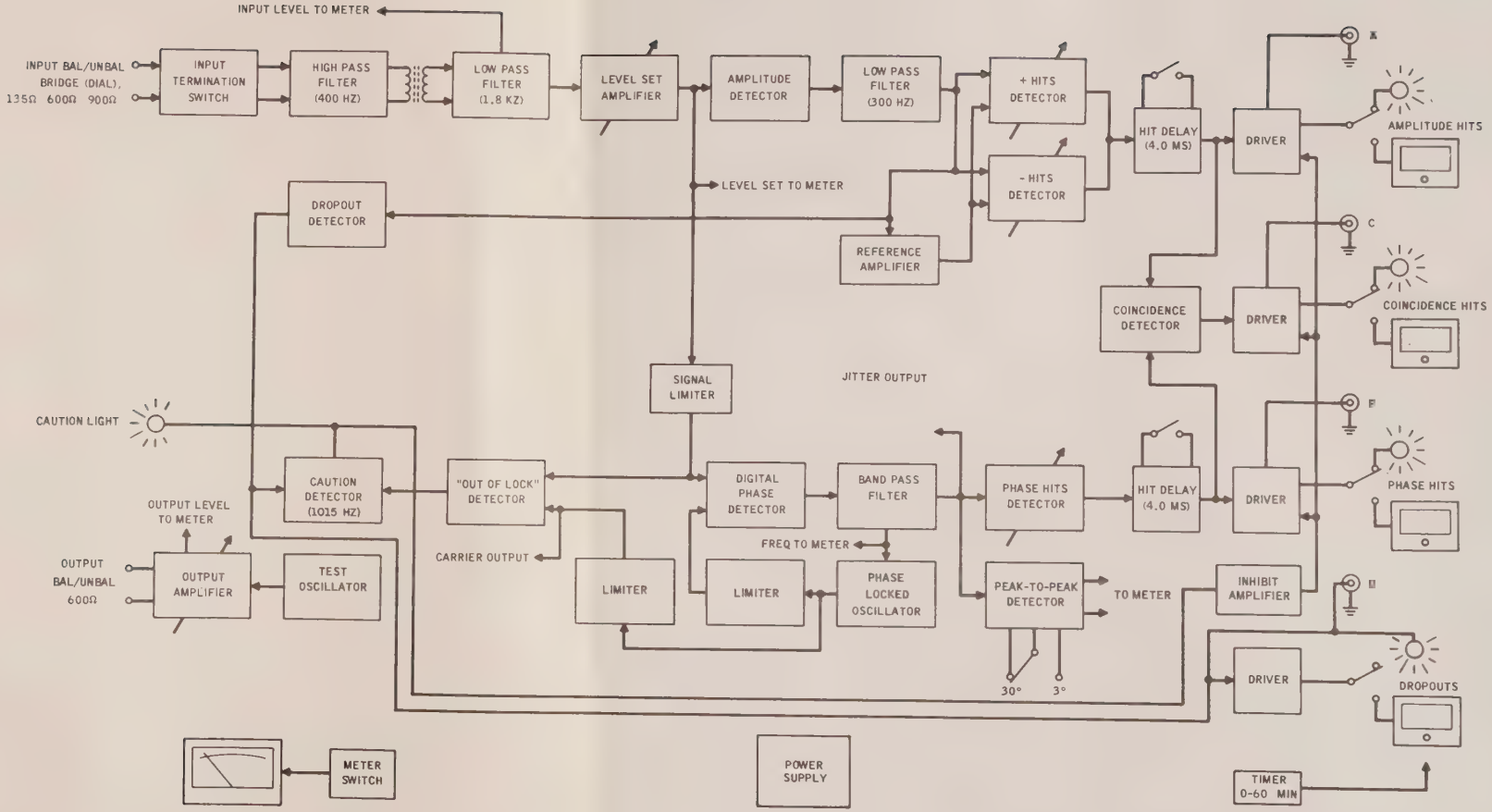



FIGURE 5-3. MODEL 48 BLOCK DIAGRAM

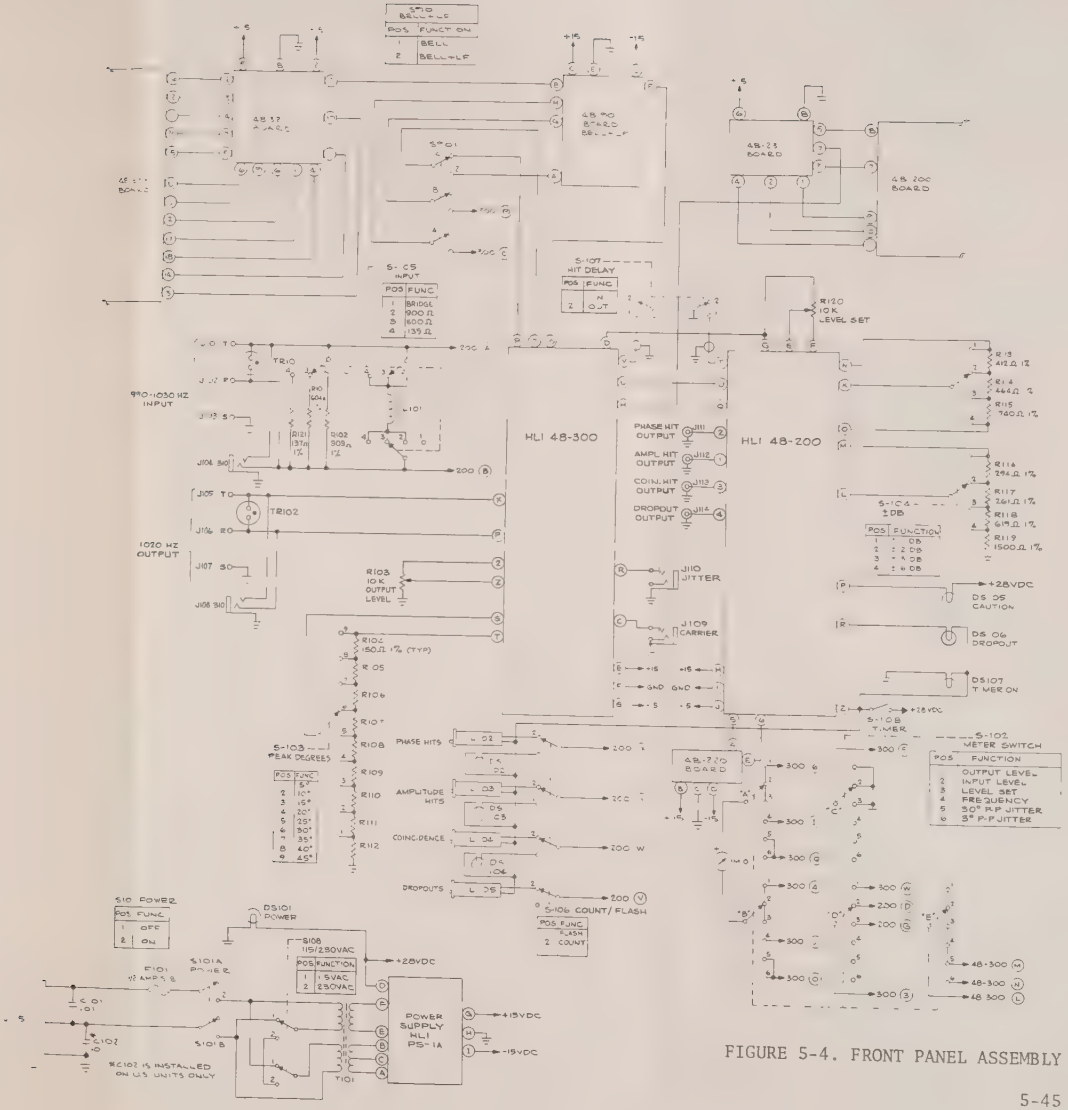



FIGURE 5-4. FRONT PANEL ASSEMBLY

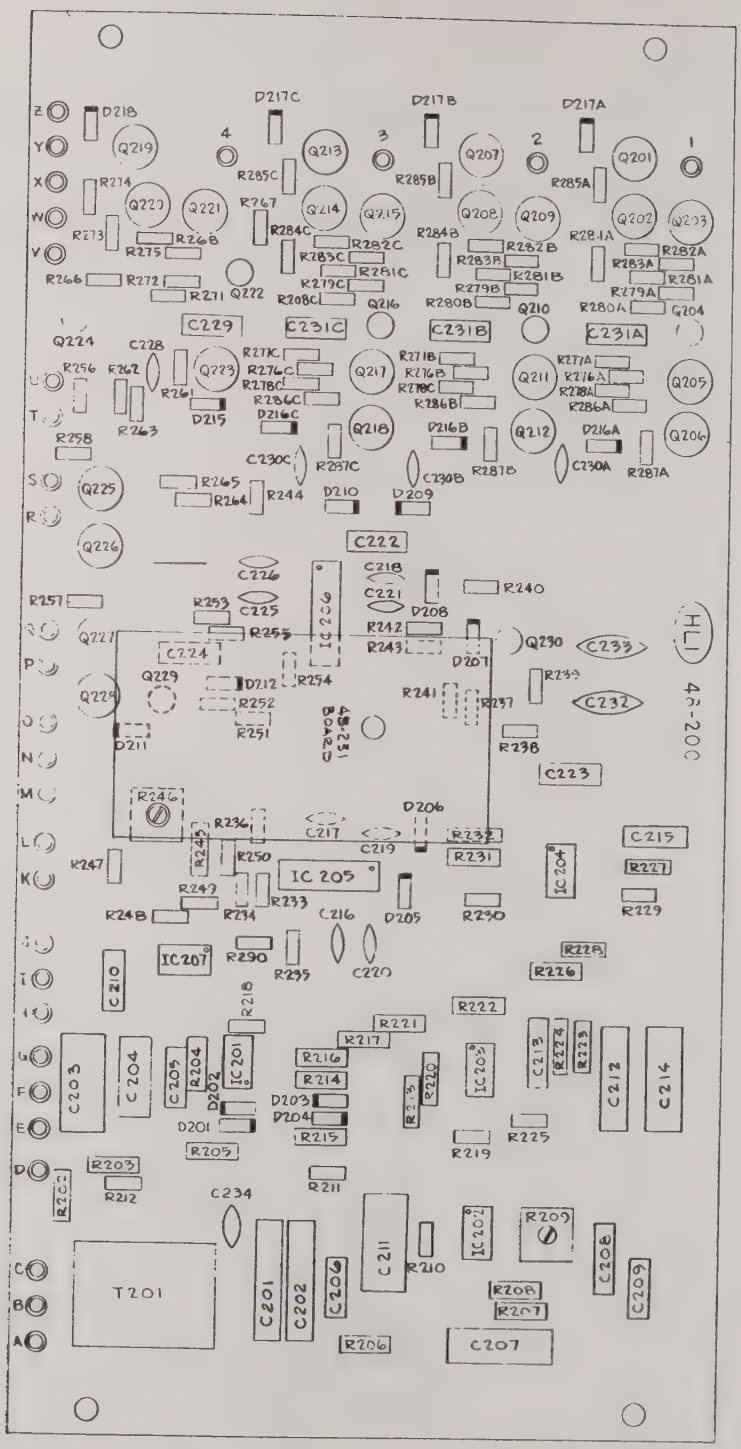



FIGURE 5-5. AMPLITUDE/HIT BOARD COMPONENT LAYOUT

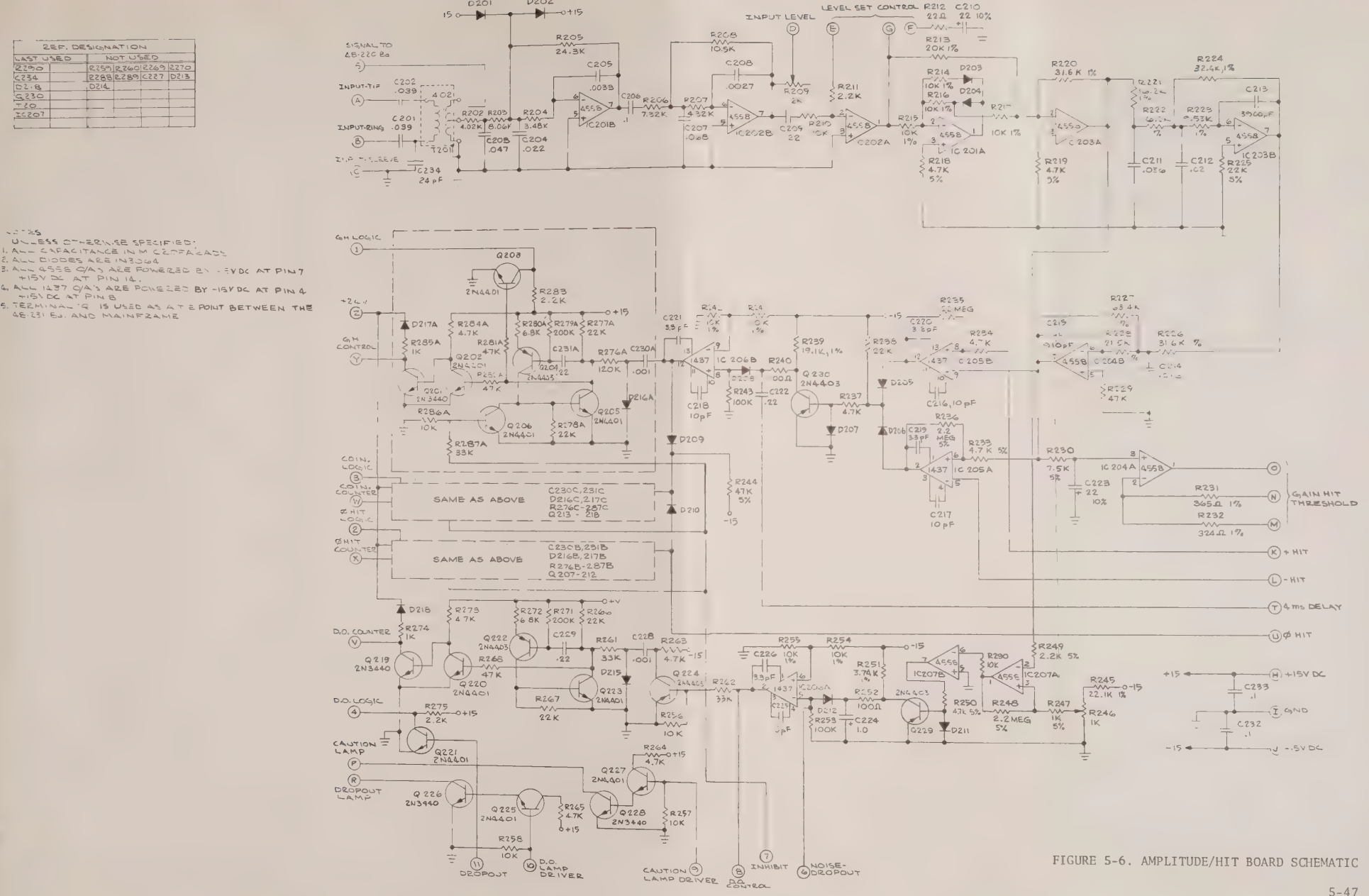
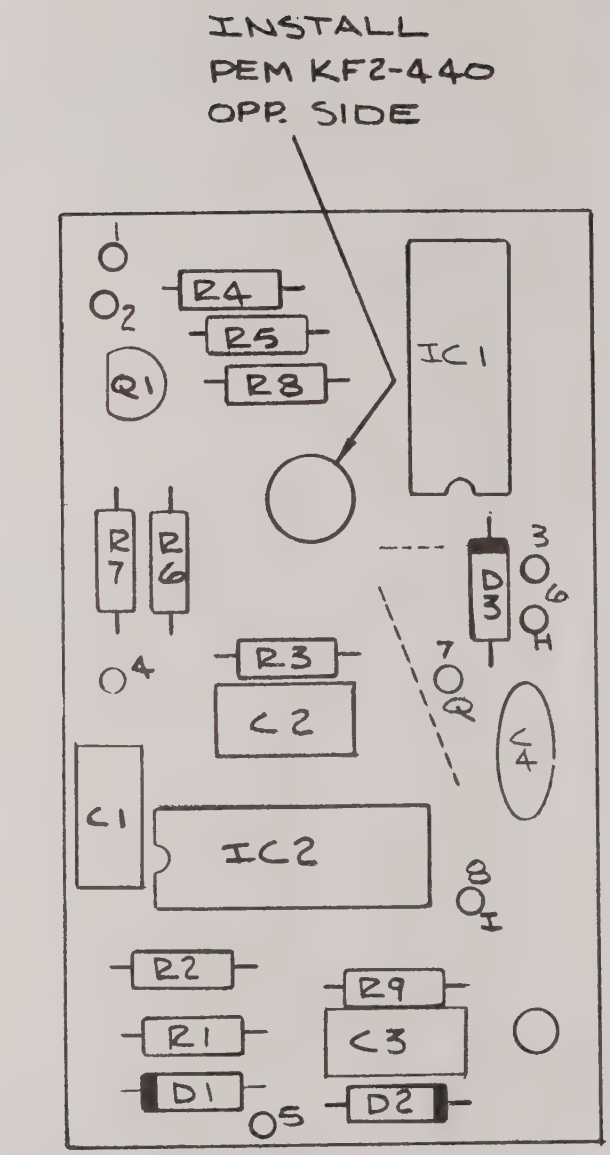



FIGURE 5-6. AMPLITUDE/HIT BOARD SCHEMATIC




NOTE:
JUMPER WIRE SIZE - #24, TEFLON SLEEVING.

FIGURE 5-7. INHIBIT BOARD COMPONENT LAYOUT

NOTES

UNLESS OTHERWISE SPECIFIED

1) ALL RESISTORS ARE 1/4W, 1%

2) ALL CAPACITANCE ARE IN MICROFARADS.

3) ALL DIODES ARE IN3064.

4) △ INDICATES CABLE DIRECT TO ANOTHER P.C.B. (HARDWIRED)

| REF DESIGNATION | | | | |
|---|---|---|---|---|
| LAST USED | | NOT USED | | |
| R10 | | | | |
| C4 | | | | |
| D3 | | | | |
| Q1 | | | | |
| IC2 | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

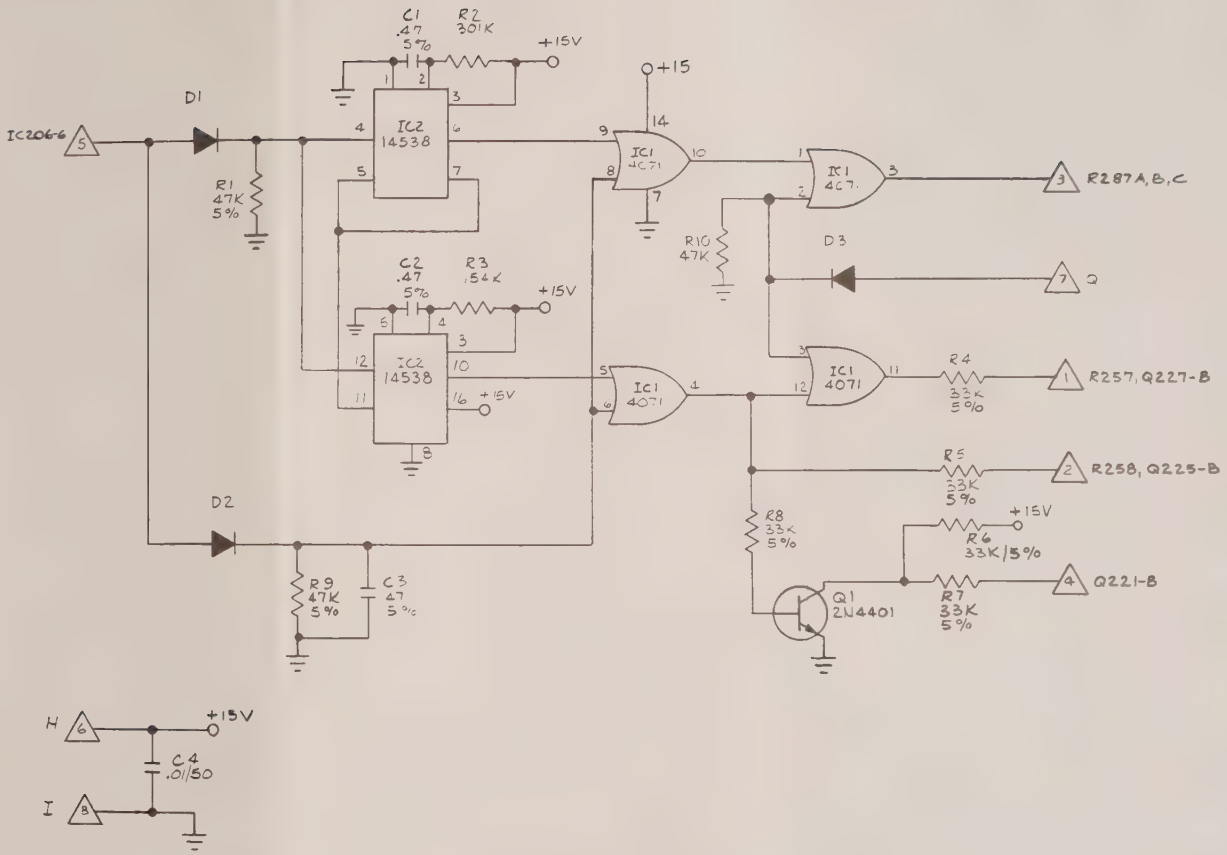



FIGURE 5-8. INHIBIT BOARD SCHEMATIC

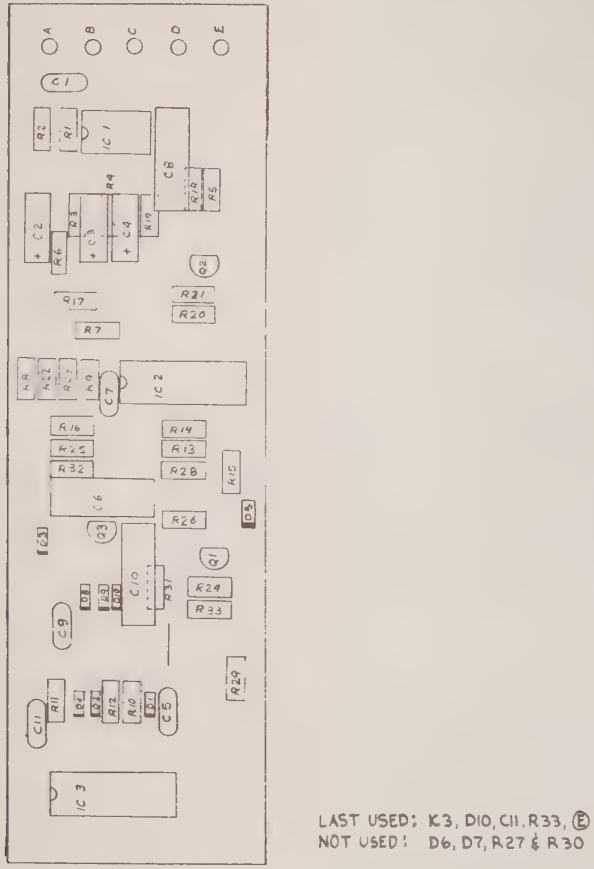



FIGURE 5-9. NOISE DROPOUT COMPONENT LAYOUT

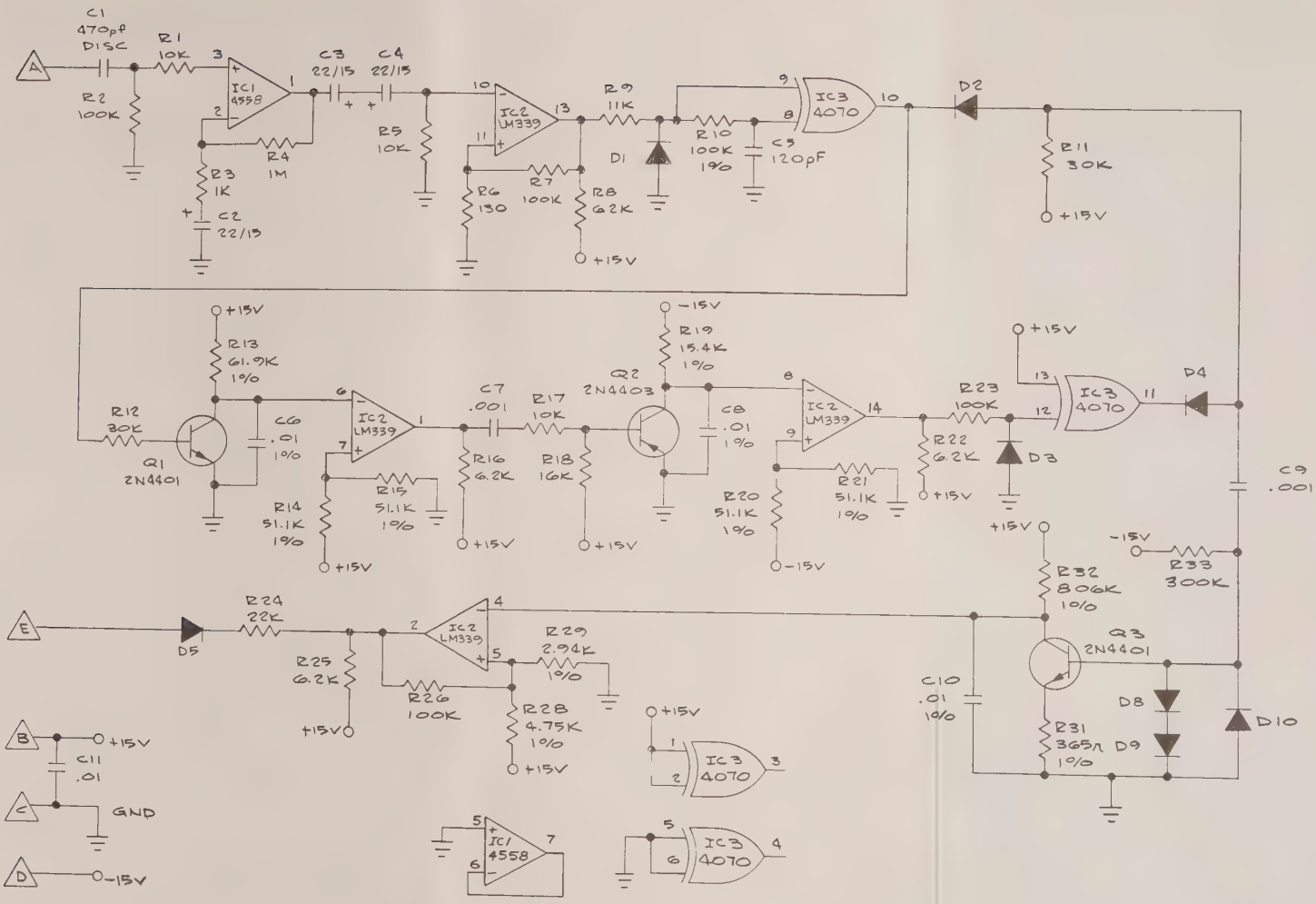



FIGURE 5-10. NOISE DROPOUT BOARD SCHEMATIC

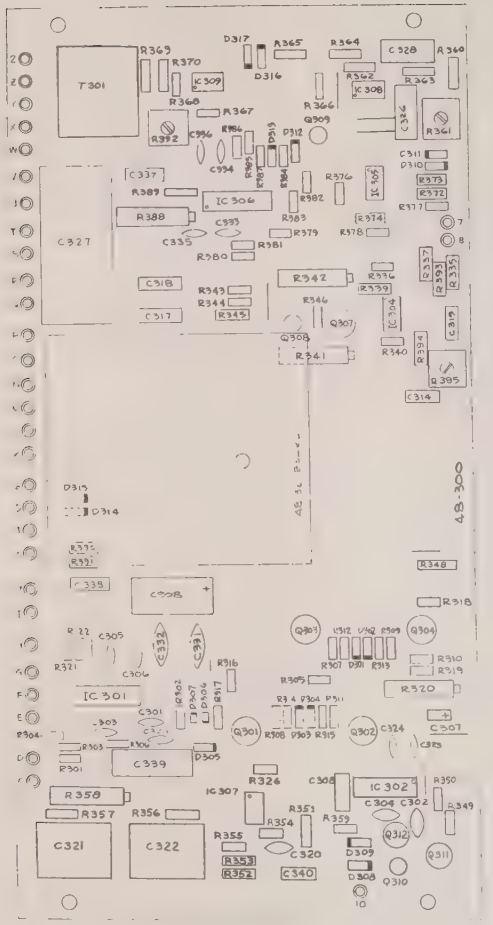
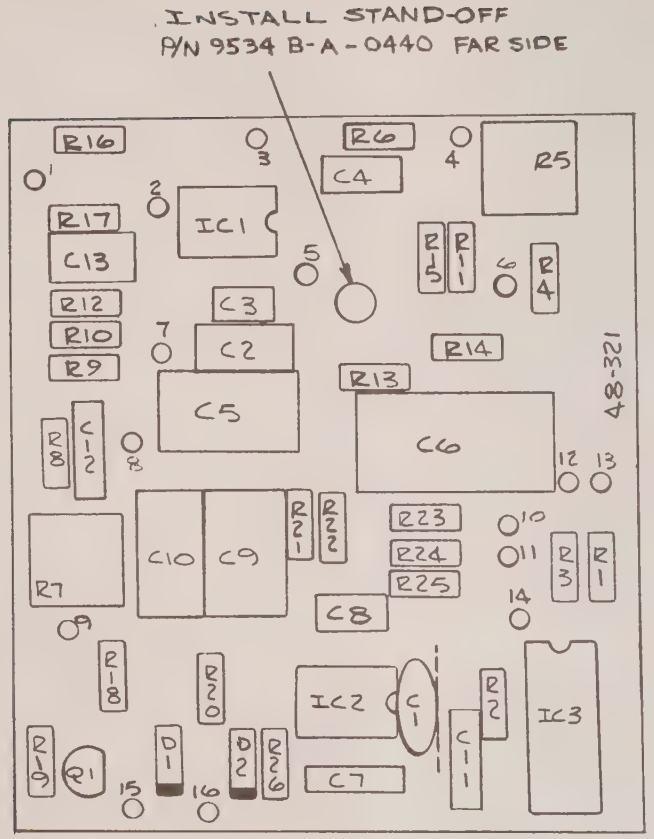



FIGURE 5-11. PHASE BOARD COMPONENT LAYOUT

| REF. DESIGNATION | | | | | | |
|---|---|---|---|---|---|---|
| LAST USED | | NOT USED | | | | |
| C395 | | C323 | C324 | C325 | C326 | C327 |
| C340 | C908 | C328 | C329 | C330 | C331 | |
| D317 | | C332 | C333 | C334 | C335 | C336 |
| Q312 | | C337 | C338 | C339 | C340 | C341 |
| IC309 | | C342 | C343 | C344 | C345 | C346 |
| | | C347 | C348 | C349 | C350 | C351 |
| | | C352 | C353 | C354 | C355 | C356 |
| | |




NOTE:
JUMPER WIRE SIZE - #24,
TEFLON SLEEVING.

FIGURE 5-13. FILTER BOARD COMPONENT LAYOUT

| REF. DESIGNATION | |
|---|---|
| LAST USED | NOT USED |
| R26 | |
| C13 | |
| D2 | |
| Q1 | |
| IC3 | |
| | |
| | |
| | |

NOTES:

UNLESS OTHERWISE SPECIFIED

1) ALL RESISTORS ARE 1/4W, 1%, WITH VALUE IN OHMS
2) ALL CAPACITANCE ARE IN MICROFARADS,
3) ALL DIODES ARE IN3064
4) ALL O/A ARE RC 4558CDI
5) △ INDICATES CABLE DIRECT TO ANOTHER P.C.B. (HARD WIRED)

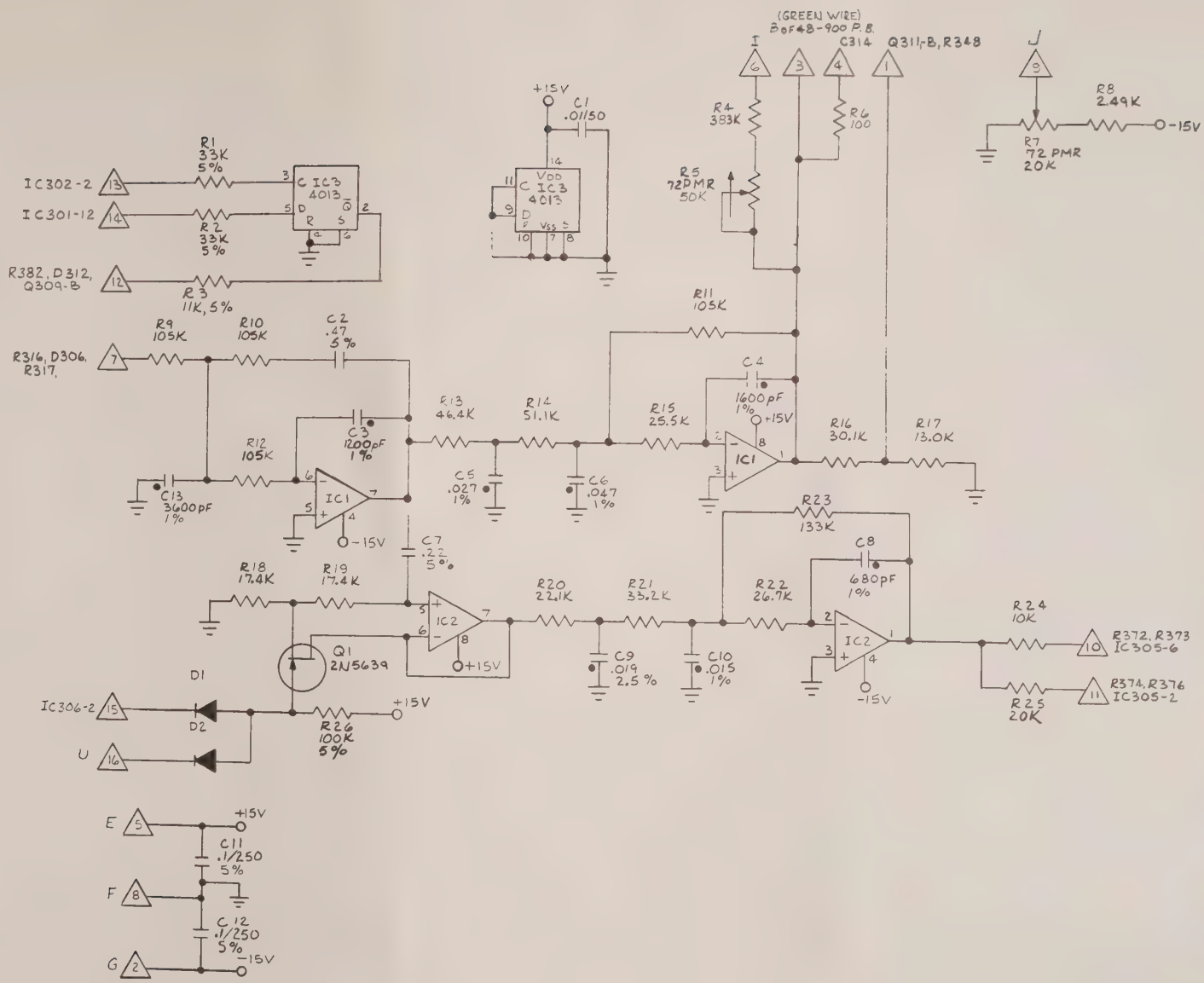



FIGURE 5-14. FILTER BOARD SCHEMATIC

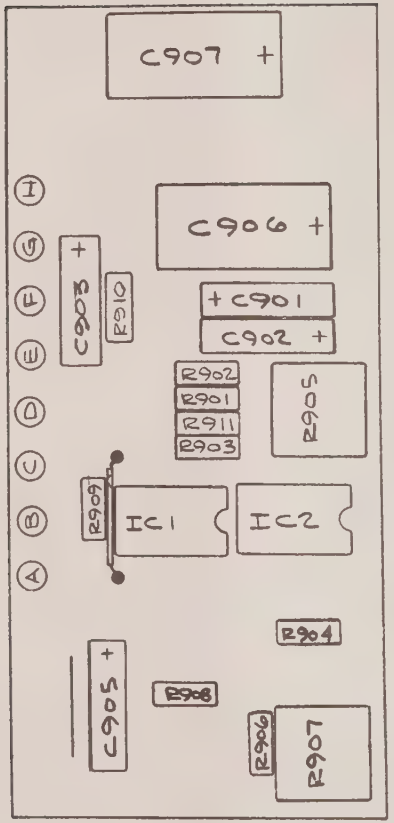



FIGURE 5-15. LF JITTER COMPONENT LAYOUT

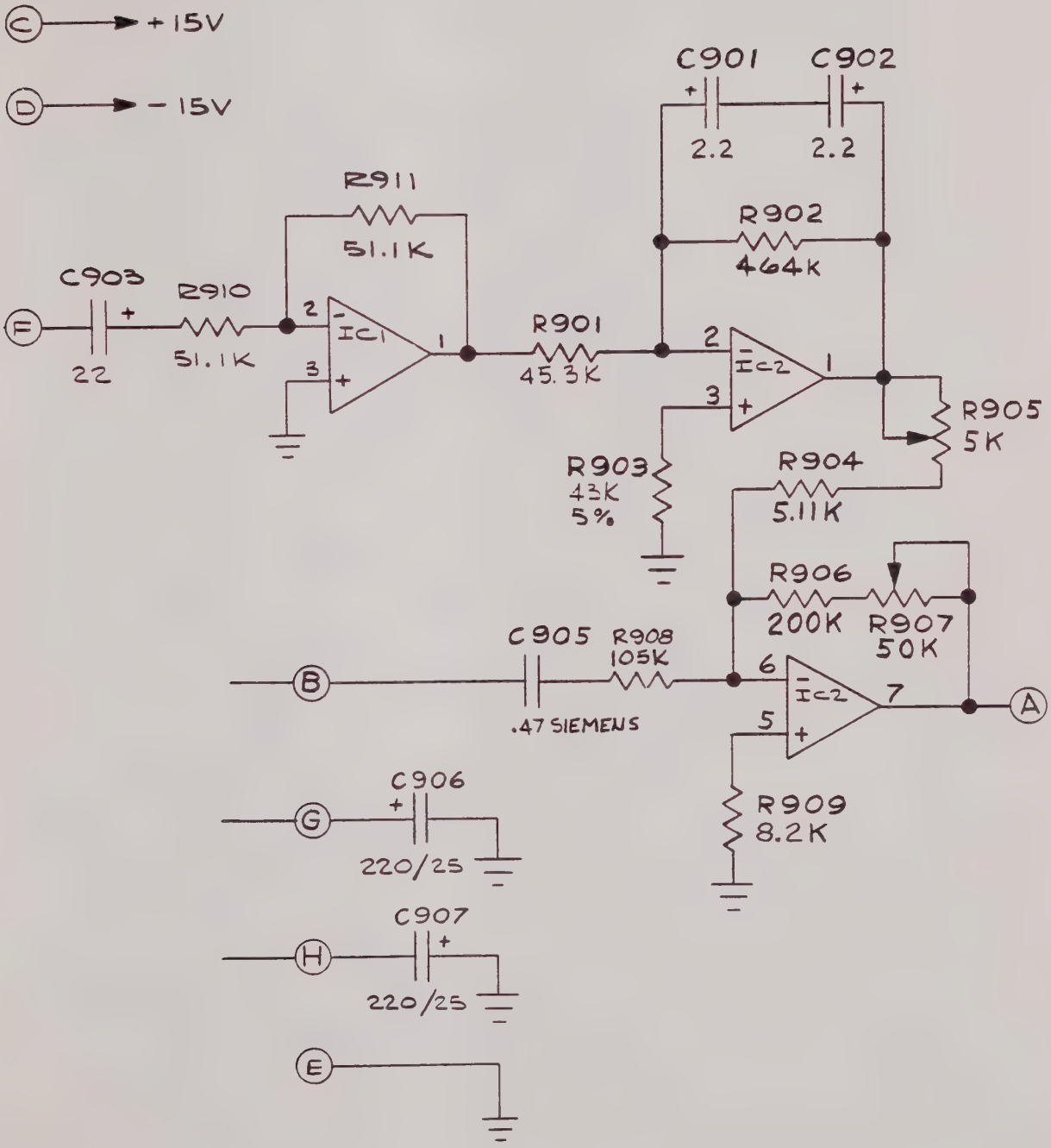



FIGURE 5-16. LF JITTER SCHEMATIC

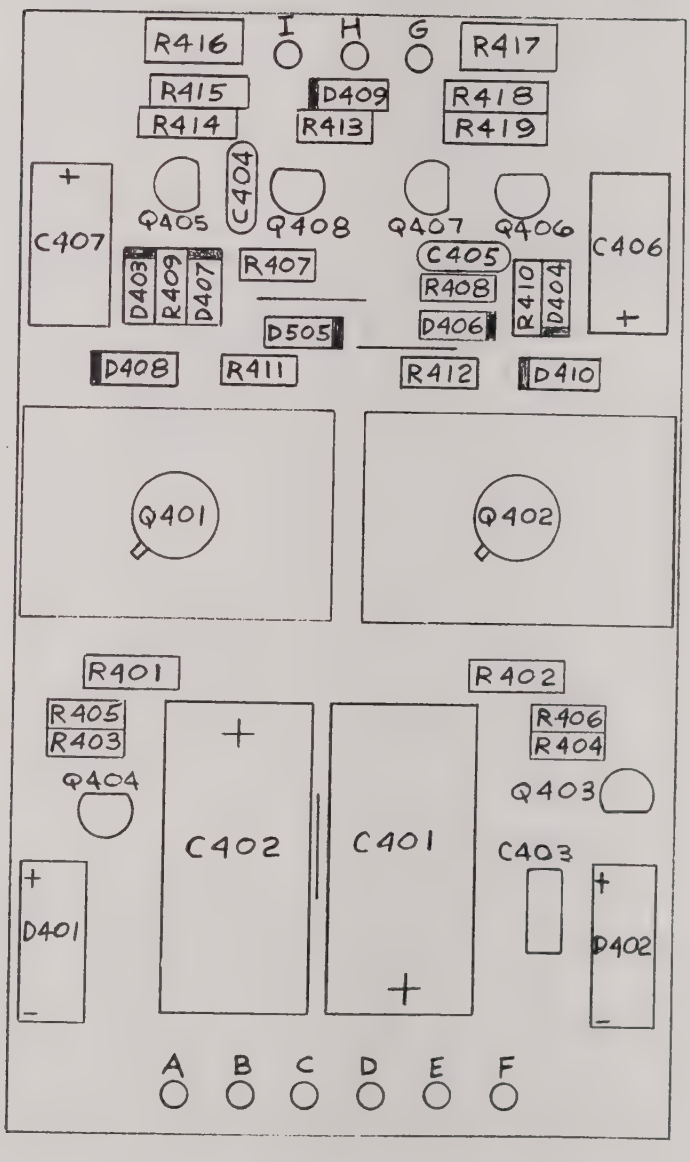



FIGURE 5-17. POWER SUPPLY COMPONENT LAYOUT

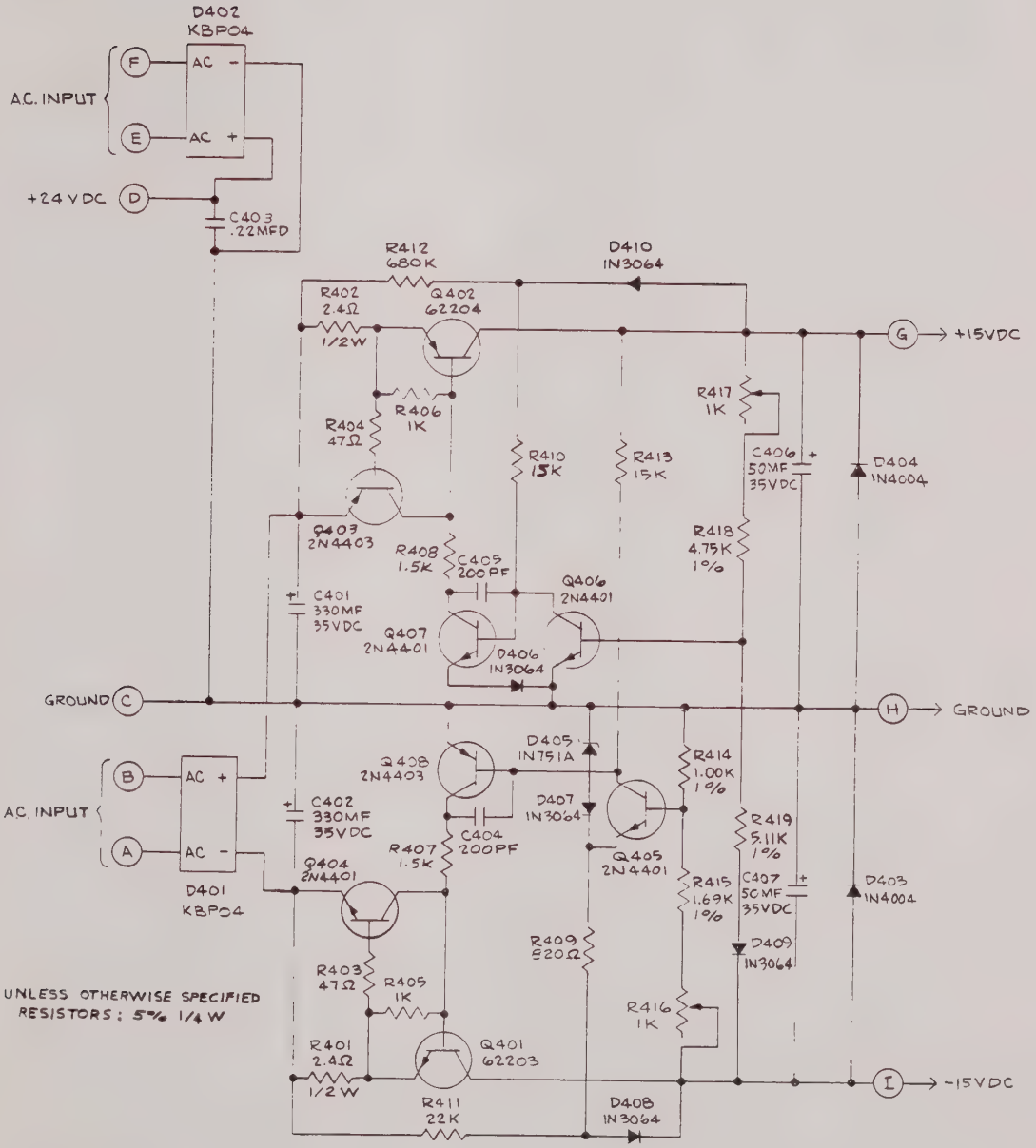



FIGURE 5-18. POWER SUPPLY SCHEMATIC

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